Title:
Environmental Audit for CIMERWA Plc

Environmental Audit report for CIMERWA PPC

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ACRONYMNS

BOD	Biological Oxygen Demand
Cd	Cadmium
CO	Carbon monoxide
COD	Chemical Oxygen Demand
Cr	Chromium
DO	Dissolved Oxygen
EA	Environmental Audit
FC	Fecal Coliforms
HC	Hydrocarbons
HFO	Heavy fuel oil
Hg	Mercury
MoE	Ministry of Environment
NOx	Nitrogen oxides
O&G	Oil and Grease
Pb	Lead
PM	Particulate Matter
REMA	Rwanda Environment Management Authority
RSB	Rwanda Standards Board
REMA	Rwanda Environment Management Authority
SO_2	Sulphur dioxide
TDS	Total Dissolved Solids
TN	Total Nitrogen
ToRs	Terms of Reference
TP	Total Phosphorus
TSS	Total Suspended Solids
UR	University of Rwanda
Zn	Zinc

GLOSSARY AND DEFINITION OF TERMS

Definition of terms used in the Environmental Audit were drawn from EA guidelines for Rwanda (REMA, 2009)

Audit conclusion: Professional judgment or opinion expressed by an auditor about the subject matter of the audit, based on and limited to reasoning the auditor has applied to audit findings.

Audit criteria: Policies, practices, procedures or requirements against which the auditor compares collected audit evidence about the subject matter.

Requirements may include but are not limited to standards, guidelines, specified organizational requirements and legislative or regulatory requirements.

Audit Evidence: Verifiable information, records or statements of fact. Audit evidence, which can be qualitative or quantitative, is used by the auditor to determine whether audit criteria are met. Audit evidence is typically based on interviews, examinations of documents, observation of activities and conditions existing results of measurements and tests or other means within the scope of the audit.

Audit Findings: Results of the evaluation of the collected audit evidence compared against the agreed audit criteria.

Auditee: Organization to be audited, in this case the Industry.

Auditor (Environmental): Person qualified to perform environmental audits.

Clients: Organization commissioning the audit. The client may be the auditee, or any other organization which has the regulatory or contractual right to commission an audit. In our case of this study, REMA is the client.

Environmental audit: Systematic, documented verification process of objectively obtaining and evaluating audit evidence to determine whether specified environmental activities, events, conditions, management systems, or information about these matters conform to audit criteria, and communicating the results of this process to the client.

Lead auditor (Environmental): Person qualified to manage and perform environmental audits. She/he leads the team of auditors.

Organization: Company, corporation, firm, enterprise, institution or association, or part thereof, whether incorporated or not, public or private, that has its own function(s) and administration.

Subject matter: Specified environmental activity, audit, event, condition, management system and/ or information about these matters.

Technical expert: A person who provides specific knowledge or expertise to the audit team, but who does not participate as an auditor.

Environmental management System: That part of the overall management system which includes the organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining an environmental policy.

EXECUTIVE SUMMARY

CIMERWA Plc is a cement manufacturing industry that has existed in Rwanda since 1984, over 36 years, located in Rusizi District, Muganza sector, Shara cell, Nyenyeri and Kabarore cells. In 2015, it commissioned a new cement manufacturing factory of dry process capable of producing 600,000tons of cement per annum, replacing an old factory of wet process that had a capacity of producing 100,000 tons per annum.

Upon commencement of the new cement industry, the village communities of Nyenyeri and Kabarore begun to complain of negative effects of the industry activities. These two communities presented their complaints to their immediate local leadership, Muganza sector, Rusizi District and went on as far as the Ministry of Environment (MoE) and Ministry of local government for redress. The outstanding complaints comprised of; dust and noise pollution, vibrations resulting in cracks of their houses and flooding of some of Nyenyeri village homes from the stormwater discharged from Cimerwa.

Based on these complaints and as the objective of this assignment, it was relevant for Cimerwa Plc to commission an environment audit to determine Cimerwa's level of compliance towards national standards of ambient air quality specifications, noise and vibration standards and public consultations to understand the context of the issues faced by the affected village communities and propose solutions in form of corrective actions that could be adopted in decision making by Cimerwa Plc and relevant authorities to avoid and mitigate issues raised.

The Environmental Audit scope was restricted to aspects and impacts emerging within the boundaries of raw materials transportation from Amashyuza limestone quarry and within the new cement production plant operations but excluding quarrying operations, the old industry and cement product transportation.

The methodology applied in this audit involved monitoring of ambient dust level at sampled locations on the new factory site, the neighbouring communities in comparison to samples taken from a baseline site location envisaged not to have any impact from the factory. Results from this exercise indicated the levels of dust exposure to the factory's neigbouring communities compared to the baseline site communities. Ambient dust levels were also taken at 50m interval distances from the Amashyuza quarry road to determine the effect of dust pollution on the communities along this road from Cimerwa truck raw material transportation. The methodology of the audit also involved noise and vibration monitoring levels with n the cement factory site and the neighbouring communities to determine whether both industrial and residential applied standards were complied to by the new Cimerwa factory.

The Audit also involved monitoring of the stormwater quality discharged from Cimerwa Factory premises against applicable standards to determine its level of compliance towards acceptable levels of discharge to the environment.

Also, as part of the methodology, the Environmental health and safety (EHS) assessment of the factory was carried out based on a list of criteria from the 2014 sector specific industry environmental audit guidelines.

Public consultations of representatives of the neighbouring communities of Nyenyeri and Kabarore villages, local authorities of Shara cell, Muganza sector, Rusizi District and Cimerwa were also carried out to obtain information on the factory's impacts on their livelihoods and the environment.

Key findings related to Cimerwa's location relative to the zoning of the area showed that Cimerwa cement factory is located in an area still zoned as residential, as many settlements have developed and continue to develop in its proximity in the 35 years of its existence, resulting in the complaints by neighbouring communities of pollution by Cimerwa. To this effect, the District has not conducted a masterplan to change the type of zoning that will inform the acceptable land use type and hence the applicable standards of compliance. i.e. Industrial or residential.

Key findings of the Environmental audit with regard to the status of conformity of the new factory of Cimerwa Plc towards National policy and legal framework, National and international standards, as well as to environmental, health and safety performance indicate that Cimerwa conformed to standards of permissible vibration levels, permissible limits of BOD, Cl-, SO_4^{2-}, NO_3^-, PO_2^{4-}, Oil and grease and Zn, most of the EHS requirements.

However, due to factors involving; its location surrounded by a residential area with a relatively high-density population, by virtue of the cement process that emits dust, noise and vibration, Cimerwa did not conform in the following manner:

- Higher PM_{10} and $PM_{2.5}$ dust levels at sample locations in neighbouring sites to the factory compared to the baseline site were observed, showing that these neighbouring sites were subjected to more dust level than the baseline by virtue of proximity to Cimerwa.
- For areas along the road from the quarry, areas less than 150m from the road are the most dust polluted.
- Noise levels are above the residential and silence zone permissible standards for most sites outside the factory boundaries up to a radius of 500m from the factory, probably a result of noise from cement production processes, mostly ball mills, crushers and kiln and also the comparison of noise levels from an industry against residential noise standards.
- Stormwater sample discharged from Cimerwa showed non-compliance to permissible limits of pH, conductivity, TDS, TSS, turbidity, COD, Pb, Cu, Cd and Cd heavy pollution of sediment at point of discharge.
- Cimerwa implemented most of the mitigation measures proposed in the 2009 ESMP for the new cement plant but was short on implementing some of the measures including; a green belt with earth mounds around its boundary to suppress noise and dust, storm water and runoff control systems on site to minimize the quantities of suspended material carried off site.
- Ambient air quality monitoring in and outside of the factory premises are not monitored and only stack emissions are monitored.
- Other than occupation noise survey conducted in 2019 by RSB, there were no records of noise levels monitored on premises and its noise impact on the neighbourhood.

These non-conformities in certain instances relate to some of the complaints raised by neighbouring communities, such as noise and dust and are mostly based on comparison to residential standards but most of them could be compliant if the area of Cimerwa's location was zoned Industrial and hence compliant to Industrial standards.

Recommendations of actions to be taken towards rectifying non-conformities by Cimerwa have been elaborated as the corrective action plan in this report. Most of the corrective actions presented are the full responsibility of Cimerwa Plc to implement, with a couple of exceptional responsibility shared with Rusizi District. The recommended actions are presented herein:

- First of all, the issue of zoning of the area between Industrial and residential needs to be discussed and resolved by Rusizi District. This will rectify the compliance requirements of the factory from residential to only Industrial standard requirements and minimize the increment in settlements closer to the factory.
- Basing mainly on Cimerwa's non- compliance towards residential standards as per its current area zoning, it is recommended that a buffer zone be established between the factory and closest resident that is at least 500 m from the Industry chimney by relocating those within this 500m radius, based on the recommendation of 500m from

the industry chimney from 2017 Rwanda National land use planning guidelines and also backed data from this audit that showed acceptable noise levels were obtained at 500 m from the factory.

  - This relocation may be approached by freezing new constructions first, and gradually resettling the existing residents starting by the most exposed to industrial dust and noise pollution of Nyenyeri community.
  - Options of areas proposed in case of relocation during the public consultation for consideration by Cimerwa were: Cimerwa owned land in Rubero village in shara cell and Mashesho cell.
  - In case relocation is pursued, it is recommended that the option of land for land is applied rather than cash for land to avoid squandering of cash by affected communities.
  - The buffer zone once in place can be planted as a green belt with trees and plants to suppress noise and dust from the neighbourhood.

- Install noise mufflers/silencers in the high noise emitters. i.e. the mills and crushers, could reduce noise emissions. Once installed, mufflers must be cleaned on a regular basis to be effective at reducing noise, otherwise, they actually can increase noise levels.
- Sedimentation settling tanks have been proposed as a wastewater treatment system for treating stormwater cement water effluent to levels permissible for discharge to the environment. Regular self-monitoring of effluent discharged by the treatment to the environment is also subsequently recommended at least quarterly.
- To minimize dust pollution along the Amashyuza quarry road, the following actions are proposed:
  - Continuous water spraying of the road to reduce dust raised.
  - To slow down trucks that raise dust, measures should be put in place by Cimerwa in collaboration with local authorities and police. Such measures comprise; enforcing lower speed limits and adjusting speed governors in trucks to that effect, speed limits along the road more enforced, humps placed along the road.
  - Consider paving the road with asphalt.
- Continuous ambient air quality monitoring could be done to establish compliance towards tolerance limits of National and international standards. This can be done and results diligently submitted to REMA for review and record purposes. This will establish that workers and surrounding communities are not exposed to pollutants that could eventually cause health hazards.
- Preferably noise mapping of the plant and noise level monitoring for the different factory departments and also the extent of its impact to the neighbourhood could be done to establish compliance towards tolerance limits of National and international standards. This can be done twice a year and results diligently submitted to REMA for review and record purposes. This will establish that either workers and the neighbourhood are not exposed to unacceptable noise levels that could eventually result in deafness.

1 INTRODUCTION

CIMERWA PPC Ltd is a cement manufacturing industry that has existed in Rwanda since 1984, over 36 years, located in Rusizi District, Muganza sector, Shara cell, Nyenyeri and Kabarore cells.

Up until 2014, Cimerwa operated the old industry wet cement production process that produced about 100,000tonnes per annum of cement and used the Electrostatic precipitator (ESP) system for filtering dust particles from industry emissions, before closing it and commissioning a new cement industry in 2015 that is a dry cement production process with a target or raising production to 600,000tones per annum of cement and a new plant that uses Bag house filters (BF) to treat dust particles.

The new industry was constructed within closer proximity to the Nyenyeri village residential community than the old industry. Also, a mobile crusher was shifted from the quarry to the entrance of the new cement industry in close proximity to Kabarore village residential community.

Upon commencement of the new cement industry, the village communities of Nyenyeri and Kabarore begun to complain of negative effects of the industry activities. These two communities presented their complaints to their immediate local leadership, Muganza sector, Rusizi District and went on as far as the Ministry of Environment (MoE) and Ministry of local government for redress. The outstanding complaints comprised of; dust and noise pollution, vibrations resulting in cracks of their houses, flooding of some of Nyenyeri village homes from the stormwater discharged from Cimerwa and effects of overflow water from the storage tank above Kabarore village.

In response to instructions by MoE to address these complaints, Cimerwa Plc proposed an Environmental audit (EA) is performed for the new plant to guide decisions to be taken as solutions to issues raised by the neighbouring village communities.

It is in this regard that Cimerwa Plc recruited Eco-excellence consultancy Ltd, a consulting firm, to conduct an Environmental Audit (EA) of its new plant.

1.1. Objectives of the Audit

The main objective of this environmental audit was:

i. To determine the level of compliance of Cimerwa Plc towards National standards and where possible relevant international standards of; stack dust emissions, ambient air quality, noise and vibrations, discharged stormwater quality and Environmental health and safety criteria from the sector EA guidelines.
ii. To verify the impacts of the activities of the new Cimerwa plant on the neighbouring communities as per complaints raised and propose solutions in form of corrective actions that could be adopted in decision making by Cimerwa Plc and relevant authorities to avoid and mitigate issues raised.

1.2. Scope of the Audit

The EA scope was restricted to aspects and impacts emerging within the boundaries of raw materials transportation from Amashyuza limestone quarry and within the new cement production plant operations but excluding quarrying operations, the old industry and cement product transportation.

The scope activities comprised of; monitoring ambient air quality, reviewing existing data from Cimerwa of stack dust emissions, monitoring noise and vibration levels, discharged stormwater quality against agreed standards and Environmental health and safety criteria from National sector EA guidelines and of importance public consultation of affected communities and relevant key informants.

In order to proceed with the EA of Cimerwa Plc newer plant, it was crucial to visit the industry and its neighbourhood in order to understand the cement production process from raw material to final product, mode of daily operation, likely waste generated, its location and context of complaints raised by the surrounding communities of Nyenyeri and Kabarore villages. This gave the consultant a general insight on the issues at hand, industry's environmental performance and an understanding of what areas the Audit would focus on for industrial impact specific to air, water, noise, vibration and stormwater quality.

1.3. Challenges related to Cimerwa activities towards the surrounding environment.

Due to close proximity of the new plant to the neighbouring village communities, industry activities have resulted in complaints from Nyenyeri and Kabarore villages, which comprised of:

- Loud noise from the new plant operations.
- Cement and coal dust from the new industry polluting their food, rainwater harvested, their homes, affecting their roofs and trees, causing them eye infections and respiratory distress.
- High levels of vibration resulting in the cracking of house walls and for some collapsing.
- Storm water from the new industry causing flooding of some houses and for some houses destroying them in Nyenyeri village community.

The two village communities have for a while submitted complaints through letters to the different authorities, local and central government, for redress. Previous visits were conducted by REMA to understand the context of the raised complaints and meetings between Cimerwa Plc, the MoE and REMA have happened in order to address these complaints raised by these communities.

1.4. Relevance of the Audit

Based on the challenges from the industry's operations and in an effort to find conclusive solutions, it was relevant for Cimerwa Plc to commission an environment audit focusing mainly on air, noise, vibration, stormwater quality monitoring, environmental health and safety, public consultation, all in order to determine Cimerwa's level of compliance towards national and international standards of ambient air quality specifications, noise and vibration standards and public consultations to understand the context of the issues faced by the affected village communities.

This exercise was done as a means to determine measures that can be proposed for implementation to minimise the industry's air, noise pollution, vibration and storm water effects and most importantly propose corrective actions that can be advanced towards solving the complaints raised by neighbouring communities of the industry's effects on their health and livelihood.

2 APPROACH AND METHODOLOGY

2.1. Approach to the Audit

The approach to the audit commenced with understanding expectations of the main objectives of the assignment, which were to;

- Assess the impacts of industry dust emissions, noise and vibration and storm water to the nearby environment in regard to compliance to applicable standards, with focus on impacts on the neighbouring Nyenyeri and Kabarore villages.
- Estimate the spatial extent of the areas that are most affected by the industry emissions.
- Propose corrective actions towards addressing impacts of the industry on the environment and addressing complaints raised by the two neighbouring villages.

In order to understand the issues at hand of the effects of the new plant's activities on the environment and community, the Environmental Audit carried out field visits and public consultations of the neigbouring villages, Cimerwa staff, relevant local government authorities and other relevant stakeholders.

This was followed by collecting primary data by monitoring dust emissions, spatial extent of ambient air quality pollution, noise, vibration and stormwater quality monitoring and performance of the industry's environmental, health and safety management systems against National, international standards, legal and regulatory frameworks.

Analysis of results from primary data were only able to indicate levels of compliance or non-compliance of the industry, but not able to give reasons for non-compliance, likely impacts resulting from non-compliance, and also not be able to respond to complaints raised by neighbouring communities or provide mitigation measures to avoiding or minimizing these impacts.

The Audit further needed to build secondary data for the industry on likely causes of non-compliance, impacts caused by their activities and solutions to these impacts. This was done through literature review of; the process flow and mass balance of Cement industries, common impacts observed from activities of cement industries, legal and regulatory frameworks relevant to these industries, previous correspondences of complaints and inspections of the industry (if any) and best available techniques (BAT) to mitigate impacts caused by this type of industry.

Findings from the public consultations, primary data collected, secondary data from literature review and environmental, health and safety performance of the industry, were assessed, from which anticipated environmental impacts were drawn, their likely causes and mitigation measures proposed.

Issues raised from the public consultation of neighbouring communities of the industry and other key informants were analysed and compared with the extent of influence from scientific dust emissions, air, noise, vibration, storm water quality monitoring findings in order to develop measures that could avoid or minimize the impact of the industry's activities on the neighbouring communities and the environment in general.

A corrective action plan for the industry was prepared comprising of; impacts, proposed mitigation measures for action, responsible institutions, frequency and duration of implementing the action.

Conclusions of the audit were presented, summarizing the status of the conformity of the industry towards stack emissions, ambient air, noise, vibration, stormwater quality and environmental health and safety performance and their impacts to the neighbouring communities, with regard to National and international standards, legal and regulatory framework.

Recommendations of the audit were also presented, drawn from the corrective action plan to the Cimerwa Plc, to address any significant non-conformances or deficiencies, including allocating priorities for corrective action.

2.2. Methodology of the dust, noise and vibration emissions and ambient air quality monitoring

2.2.1. Applicable standards

To begin with, it was important for the Environmental Audit to know the applicable standards against which compliance levels would be measured. Ambient air pollution, noise and vibration tests were hence evaluated against the following Rwanda standards:

Table 1: Applicable standards for air pollution, noise and vibration

	Environment Impact	Applicable Standards
1.	Ambient Air Pollution (dust)	RS EAS 751: 2010
2.	Noise	RS 236: 2014
3.	Vibration	RS 237: 2014
4.	Factory Dust Emission	RS EAS 750: 2010

Ambient Dust Pollution Standards

Air quality specification standard RS EAS 751:2010 specifies acceptable levels of two types of dust; particulate matter with diameter less than 10μm (PM_{10}) and particulate matter with diameter less than 2.5μm ($PM_{2.5}$). For PM10, the standard provides different values for residential and industrial areas relevant parts of the standard are captured in table 2.

Table 2:Ambient air quality tolerance limits for dust

	Pollutant	Time weighted average	Industrial area (μg/m^3)	Residential, Rural & Other area (μg/m^3)
1	Respirable particulate matter (PM_{10})	Annual average	70	50
		24 hours	150	100
2	$PM_{2.5}$	Annual average	35	
		24 hours	75	

Ambient Noise Pollution Standards

The Rwanda standard RS 236:2014 provides ambient air quality standards in respect of noise for daytime and night-time for industrial area, commercial area, residential area and silence zone. Silence zones are defined as up to 100 m around such premises as hospitals, educational institutions, libraries and courts. Ambient air quality standards with respect to noise are provided in Table3.

Table 3: Ambient standards in respect to noise

	Category of area	Limit in dB, Max	
		Daytime	Night-time
1	Industrial area	75	70

2	Commercial area	65	55
3	Residential area	55	45
4	Silence zone	50	40

Ground Vibration Standards

The standard RS 237:2014 provides maximum acceptable limit for ground vibration in order to ensure safety of infrastructure at sensitive sites. Sensitive sites in respect to ground vibration are defined as "Any land within 10 m of a residence, hospital, school, or other premises in which people could reasonably expect to be free from undue annoyance and nuisance caused by vibration. The 10 m will be measured from the boundaries of the property".

The standard is expressed in terms of peak particle velocity (PPV) which is the maximum instantaneous sum of the velocity vectors of the ground movement measured in three orthogonal directions (expressed in millimetres per second). PPV is the maximum of instantaneous velocities V calculated following the equation (1):

$$V = \sqrt{v_v^2 + v_l^2 + v_t^2} \quad (1)$$

A maximum PPV of 5 mm/s is set for ground vibration at sensitive sites, defined above.

2.2.2. Stack dust emission measurement

Channelled emissions from the factory are those emissions that are released to the atmosphere through stack or ducts. Channelled emissions are easier to measure directly at the stacks where different technologies exist to minimize pollutants before flue gas is realised into the atmosphere.

Emissions to the atmosphere by the factory were calculated from channelled emissions by measuring the flow rates of flue gas and its pollutants concentrations. The emissions rates were compared against standards limits.

In this case, the Audit focused mainly on providing dust emissions from Cimerwa stacks/chimneys which have the main fume extraction systems at the cyclone pre-heater and the Kiln discharging emissions channelled to the stacks.

Monitoring for the two main stack/chimney emissions at the kiln and the cyclones pre-heater were taken when the factory was operating, at a sampling platform and a sampling port. During this exercise, focus was on Total suspended dust particulate matter (PM) measurement, with the possibility of measuring other pollutants such as Sulphur dioxide (SO_2), Carbon monoxide (CO), Oxides of nitrogen (NO_x).

2.2.3. Ambient dust, noise and vibration measurement

2.2.3.1. Instruments used.

The Audit used Realtime Affordable Multipollutant sensors (RAMPS) with Met-One dust monitors (Figure 1) to measure ambient dust considering particles with aerodynamic diameter less than 2.5 micrometres ($PM_{2.5}$) and those with aerodynamic diameter less than 10 micrometres (PM_{10}). It also used AirVisual Pro. to complement RAMPS on dust monitoring.

For noise monitoring, the Audit used digital sound level meters (Figure 2).

While for vibration monitoring, the Instantel Minimate (Figure 3) was used to measure the ground vibration.

Figure 1: RAMPS sensor (left) and the AirVisual pro (right) used for air quality monitoring.

Figure 2: Sound level meters used for noise monitoring.

Figure 3: Instantel minimate used to monitor vibrations.

2.2.3.2. Selected sites for sampling

The Audit team put in place sensors at five positions in the neighbourhood surroundings to the factory that were used to collect data of dust emissions, ambient air quality, noise and vibrations for analysis and comparison with the applicable standards mentioned above.

Special consideration was given to noise which has different standards for silence zones like schools and medical facilities. Silence zones available in the neighbourhood were schools and medical facilities namely, E. S. Bugarama, Shara primary school, l'Educateur primary school and Cimerwa Clinic. Separate monitoring of noise was conducted on those silence zones.

In additional to compliance monitoring, the audit also conducted measurements to assess the distance at which the neighbourhoods undergo factory dust emissions and noise and vibration pollution, mainly in Nyenyeri and Kabarore villages. To achieve this objective, the Audit followed a radial distance centred at the factory at which measurements of noise, dust and vibration were taken every 100m apart to determine the distance at which the noise and vibration start to decline compared to applicable standards and the dust compared to a baseline site that is free from direct factory dust emissions. Dust was compared to the baseline level in order to cater for dust level in the air that are not attributable to the factory emissions.

Dust monitoring was also be conducted along the unpaved road starting from the Amashyuza hot spring quarry to the factory, to assess the distance at which the neighbourhoods are affected by the dust from trucks carrying limestone raw material for cement. Dust monitoring was conducted every 50 m following a line perpendicular to the road with a slight angle to consider the direction of the wind.

Sites for dust, noise and vibration monitoring are shown in the maps of figures 4,5 and 6.

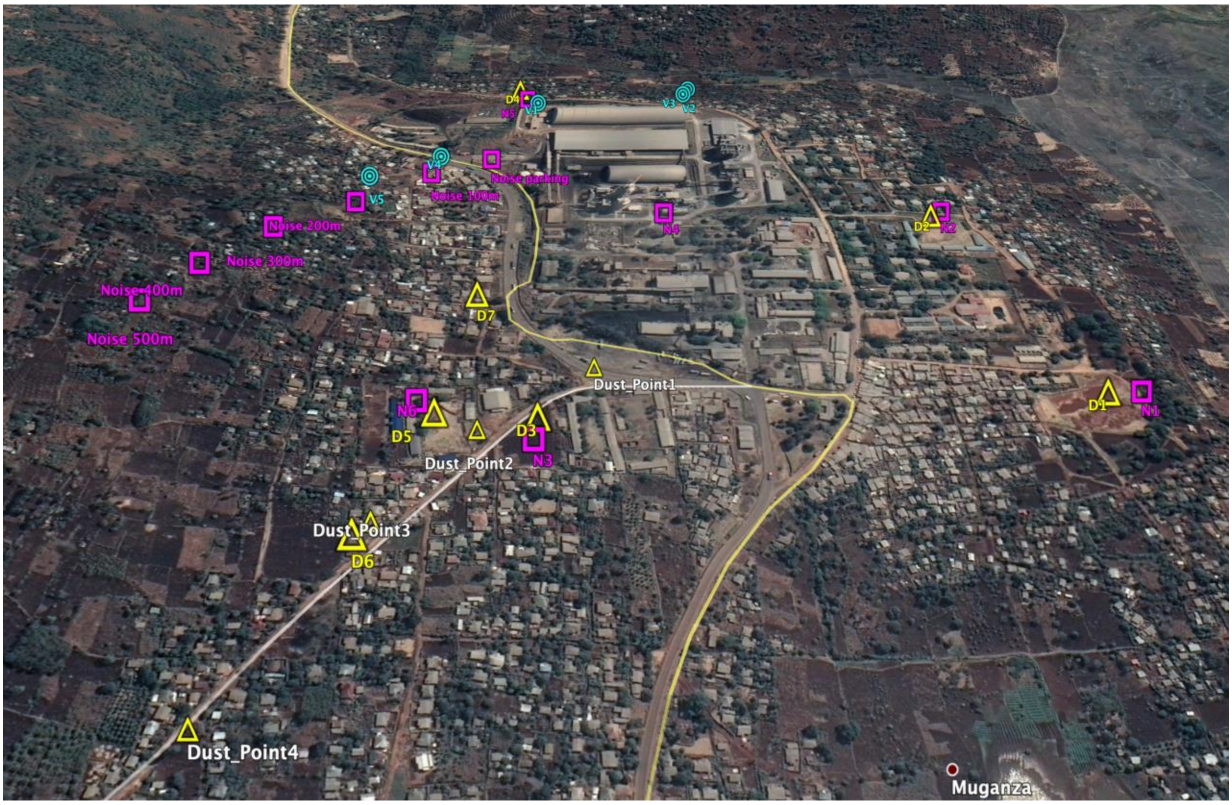

Figure 4: Sites for dust (represent by yellow triangles), noise (in magenta squares) and vibration (in cyan circles)

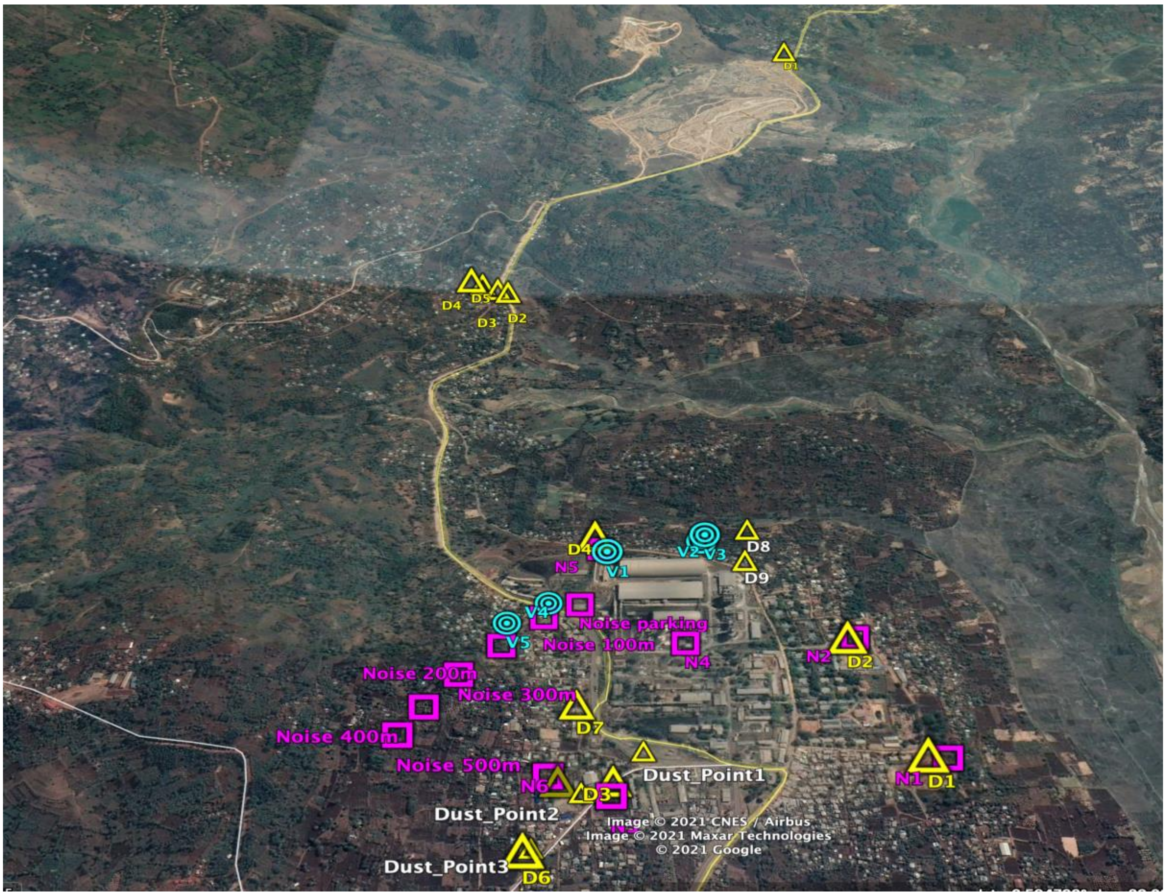

Figure 5: Location of the baseline monitoring site (D1) for road dust relative to CIMERWA quarry and the location of the road dust monitoring sites

Figure 6: Location of the road dust monitoring sites

Table 4: Coordinates of dust sample monitoring sites surrounding the factory.

Site	Latitude	Longitude
D1	-2.611412°	29.022059°
D2	-2.608445°	29.020809°
D3	-2.612096°	29.016429°
D4	-2.605404°	29.015708°
D5	-2.612145°	29.015473°
D6	-2.613715°	29.015018°
D7	-2.610312°	29.015671°
D8	-2.604901°	29.018917°
D9	-2.606069°	29.018845°

Table 5: Coordinates of dust monitoring sites to assess the geographical extent of the factory impacts of dust pollution.

Site	Latitude	Longitude
Point1	-2.611245	29.016927°
Point2	-2.612250°	29.015880°
Point3	-2.613485°	29.015129°
Point4	-2.615603°	29.014268°
Point5	-2.617332°	29.012485°

Table 6: Coordinates of dust sample monitoring sites by the quarry road

Site	Latitude	Longitude
D1	-2.580489°	29.020612°
D2	-2.595636°	29.012868°
D3	-2.595553°	29.012599°
D4	-2.595393°	29.012194°
D5	-2.595347°	29.011905°

Table 7: Coordinates of vibration sample monitoring sites

Site	Latitude	Longitude
V1	-2.605883°	29.015988°
V2	-2.605496°	29.017940°
V3	-2.605236°	29.018011°
V4	-2.607488°	29.014915°
V5	-2.608138°	29.014168°

Table 8: Coordinates of sites used to monitor ambient noise around the factory.

Site	Latitude	Longitude
N1	-2.611335°	29.022419°
N2	-2.608284°	29.020957°
N3	-2.612359°	29.016408°
N4	-2.608531°	29.017645°
N5	-2.605711°	29.015832°
N6	-2.611967°	29.015282°

N7	-2.605892°	29.019590°
N8	-2.608877°	29.013813°
N9	-2.605336°	29.018433°
N10	-2.605390°	29.018760°

Table 9: Coordinates of sites used to monitor noise attenuation with distance.

Site	Latitude	Longitude
Parking	-2.607498°	29.015533°
100 meters	-2.607909°	29.014856°
200 m	-2.608799°	29.014135°
300 m	-2.609723°	29.013472°
400 m	-2.610634°	29.012989°
500 m	-2.611350°	29.012643°

Table 10: Coordinates of sites used to monitor baseline noise levels.

Site	Latitude	Longitude
Point1	-2.626253°	29.018389°
Point2	-2.625928°	29.018493°
Point3	-2.625321°	29.018567°
Point4	-2.624880°	29.018380°

2.2.3.3. Limitations of the Audit

The major limitation of the audit was the short duration and the partly wet season the audit was carried out, which limits measurement and analysis of extreme effect of the dust emissions and ambient levels. It is expected that maximum dust pollution occurs during the dry season due to the long residence time of dust in the atmosphere as there is no rain to wash it away. The long residence time makes it possible for cumulative effect of dust pollution leading to higher pollution, which also add to a generally high dust level existing already in the region due to sources other than the CIMERWA factory.

The short duration of the Audit as opposed to a longer period may have also made it possible to miss exceptional emissions which occur sporadically and are typically due to equipment malfunction, planned maintenance or process start up or shut down by the new factory. Exceptional emissions tend to be higher than emissions that occur during normal operation.

Again, due to the short duration, seasonal change in wind speed and direction were missed when assessing the distance from the factory at which neighbourhood undergo dust and noise emissions.

The Audit, however, attempted to close gaps from these limitations by analysing records of gas emission data over a longer period availed by Cimerwa Plc.

2.3. Surface water quality monitoring

2.3.1. Sample collection and preservation process

Water samples were collected using a systematic method in order to be representative of the stormwater discharged by the industry in a manner that is reproducible, defendable and useful.

The sampling point for stormwater and sediment were at the end of the discharge channel of stormwater from the Cimerwa factory at the side of Nyenyeri village. Sampling point coordinates are latitude -2.605353^0 and 29.015786^0 longitude.

Collected water samples designated for physical-chemical analysis were collected in a plastic container. Before collecting a sample and in order to avoid any contamination, the plastic containers were cleaned and rinsed three times properly using the wastewater to be sampled.

Sediment samples were also collected in a plastic container.

All the samples were placed in cooler box with ice for transportation to the Laboratory of the School of Science/College of Science and Technology of the University of Rwanda (UR) and stored in fridge at 4^{o}C.

2.3.2. Parameters proposed and analytical protocol.

Reference was made to the study by (Ipeaiyeda & Obaje, 2017) on the impact of cement effluent, in determining the parameters to measure for stormwater surface water quality discharged by Cimerwa. The following table shows the parameters that were monitored for the quality of the storm water discharged by Cimerwa.

Table 11:Proposed parameters for water quality monitoring

	pH, TDS, DO	**COD**	**BOD**	**TSS**	**Nutrients (Cl^-, SO^{2-}_4, NO^-_3, PO^{3-}_4)**	**Oil & Grease**	**Heavy metal (Cd, Cu, Pb, Zn)**
Cimerwa	✓	✓	✓	✓	✓	✓	✓

Of the parameters in the table 11 above, the parameters that were measured in-situ were pH, TDS, Dissolved Oxygen (DO), by use of sensitive electrodes sensors that comprised of; HQ40d Portable Multi Meter pH, TDS, Dissolved Oxygen (DO), ORP for Water quality measurement.

The rest of the parameters were analysed at the Chemistry laboratory of College of Science and Technology, University of Rwanda. During laboratory analysis, UV Spectrophotometer was used for Physio - chemical analysis and Atomic Absorption Spectrometer (AAS) was used for heavy metal measurement.

Biological Oxygen Demand (BOD_5)-Biochemical Oxygen Demand expresses the amount of Oxygen utilized when the organic matter in a given volume of water is degraded biologically. Protocol that was followed in measuring it involved completely filling an airtight bottle of specified size and incubating it at 20^{o}C for 5 days. BOD_5 was calculated by taking the difference between the initial Dissolved Oxygen and the Dissolved Oxygen measured after 5 days incubation by using the LDO apparatus. The BOD_5 was obtained by the difference between the quantity of Oxygen before and after incubation procedure at 20^{o}C in darkness. BOD_5 (20^{o}C) = $[DO]_{initial}$ - $[DO]_{final}$.

Chemical Oxygen Demand (COD)-The Chemical Oxidation demand was used as a measure of the Oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant (digestion solution). The strong oxidants (Potassium Dichromate) were used to oxidize all organic matter. The reduction of Cr^{IV} to Cr^{III} indicates the presence of organic matters in water with the solution becoming green blue. The solutions used in this analysis were Ag_2SO_4, H_2SO_4 as catalyst to oxidize bio-organic matter. The reading of absorbance was done the next day at 600 nm by use of UV Spectrophotometer.

Oil and Grease-The oil and grease was determined by applying the Weibull method. This method is generally applicable for determining oil and grease from food and water. At a given concentration of HCl mostly HCl 4N releases intracellular fat or protein bound. Lipids are collected on wet filter, washed with warm water until acid disappears, then, dried and extracted with petroleum ether in Soxhlet apparatus. The ether solution is distilled, and the residue is dried and weighed to determine the oil and grease content.

Total Suspended Solids (TSS)- Total suspended solids in water are associated with natural sources, sewage urban runoff and industrial wastewater (Kihampa & Mwegoha, 2010). The gravimetric method was applied in this work, which involved the following steps; filter paper was washed and dried. It was then cooled and weighed. The filtration apparatus was assembled. The filter paper was wetted with distilled water, the sample was stirred, and a given volume was pipetted while stirring sample, it was filtered and washed three times. The filter was transferred to an evaporating dish and dried. It was cooled and weighed. TSS concentration was calculated in the following manner: mg Suspended Solids / L = [(A-B) x 1000]/ volume of sample (mL). Where: A = weight of filter + dried residue (mg), B = weight of filter (mg).

Ortho Phosphate- Phosphate was determined in wastewater samples by using UV Spectrophotometer at 880 nm. In principle, Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid – phosphomolybdic acid that is reduced to intensely coloured molybdenum blue by ascorbic acid.

For Nitrate- Also, by using a UV spectrometer, the ammonia nitrogen was determined. Ammonium nitrogen reacts with hypochlorite ions, formed by the alkaline hydrolysis of dichloro-isocyanurate and with sodium salicylate in presence of sodium nitro prussiate to form a blue dye which appears green due to the interference with yellow colour of reagents. Results are measured at 655 nm.

Heavy metals analysis- Heavy metal sediment sample analysis involved; drying the wet sediment sample in the oven at 105°C, weighing 0.5g of the dried sediment, digesting it by adding 10ml of Nitric acid (65%HNO_3) and 50ml of distilled water until there is $\pm$5ml of digested sample. The digested sample was then transferred to a 50ml volumetric flask, filled up to the mark with distilled water and then sent for heavy metal measurement. Measurement of (Pb, Cd, Cu, Zn) was done on the Atomic Absorption Spectrophotometer (AAS) in duplicate sample and each duplicate sample was measured two times.

In addition to sediment sample analysis for heavy metal pollution, stormwater sample analysis of heavy metal content to determine the actual contribution of Cimerwa to the environment in its discharged stormwater was carried out. Analysis involved digestion of unfiltered samples with Nitric Acid in order to get dissociation of metals in samples and then the samples were filtered on Glass Fibre Filters (pore size 0.45 µm, 47 mm) before analysing them to avoid the logging of the AAS aspirator capillary. The concentration of these metals was determined by Atomic Absorption Spectrophotometer (AAS) with air/ acetylene flame method.

2.3.3. Water and sediment quality standards

Surface water quality standards were important in establishing tolerable limits for the quality of water discharged to the environment that is of no or insignificant levels of pollution.

For purposes of determining the level of compliance of the industry towards discharged stormwater quality, the table below shows the standards applied in this EA.

Table 12: Referenced Standards of Surface water quality.

Parameters to be analysed	Tolerance Limit
pH	6.5 – 8.5
Total Dissolved Solids (TDS) (mg/l)	>5
Conductivity (µS/cm)	1000
Dissolved Oxygen (DO) (mg/l)	500
Chemical Oxygen Demand (COD) (mg/l)	50
Biochemical Oxygen Demand (BOD) (mg/l)	30
Total Suspended Solids (TSS) (mg/l)	30
Nitrate Nitrogen (NH_4-N) (mg/l)	10
Chloride (Cl^-) (mg/l)	250
Sulphate (SO_4^{2-}) (mg/l)	250
Phosphate (PO_4^{3-}) (mg/l)	5
Oil & Grease (O&G) (mg/l)	10
Heavy metals	
Cobalt (Co) (mg/l)[1]	-
Cadmium (Cd) (mg/l)	0.001
Lead (Pb)(mg/l)	0.01
Copper (Cu) (mg/l)	0.1
Nickel (Ni) (mg/l)[2]	0.02
Zinc (Zn) (mg/l)	3

Sediment pollution standards

The Audit was not able to able to obtain National standards for sediment heavy pollution and hence used Netherlands' sediment pollution standards from literature review of (Kelderman, et al., 2005).

Definitions of pollution classes with respect to the contents of the heavy metals; chromium, nickel, copper, zinc, cadmium, mercury, lead, of arsenic and of organic micro-pollutants for polluted sediments in the Netherlands, were classed as; Class 1(unpolluted sediment), class 2 ("lightly polluted"), class 3 ("polluted") and class 4 ("highly polluted") sediments as presented in the table below.

[1] Not measured in Rwanda.
[2] Not measured in Rwanda.

Table 13:Sediment pollution standards

Parameter (all as mg/kg, except Σ DDT and Σ PAH)	Class 1	Class 2	Class 3	Class 4
Cr	< 380			≥ 380
Ni	< 35	35 - < 45	45 - <210	≥ 210
Cu	< 35	35 - < 90	90 - < 190	≥ 190
Zn	< 480	480 - < 720		≥ 720
Cd	< 2	2 - < 7.5	7.5 - <12	≥ 12
Hg	< 0.5	0.5 - < 1.5	1.5 - < 10	≥ 10
Pb	< 530			≥ 530
As	< 55			≥ 55
Σ DDT	< 10	10 – 20	21 – 4000	> 4000
Σ PCB	< 100	100 – 200	201 – 1000	> 1000
Σ PAH	<1	1 - < 10	10 - < 40	≥ 40
Mineral oil	< 1000	1000 - < 3000	3000 - < 5000	≥ 5000

Source: (Kelderman, et al., 2005)

2.4. Public consultation

Public consultation was an essential exercise of this audit, where the Auditor engaged the affected communities, Cimerwa, local authorities and other relevant stakeholders, in order to understand the origin of complaints, the source of the problems, each sides point of view and their proposed solutions to avoid or mitigate the impacts.

The method of consultation proposed that was used was key informants' interviews (KIIs). The method of Focal Group Discussions (FGDs) was not possible considering restrictions to reduce the spread of Covid-19.

The Auditor carried out public consultation mainly with the following key informants:

- Representatives and leadership of Nyenyeri village community.
- Representatives and leadership of Kabarore village community.
- Representative from Shari cell office.
- Representatives from Muganza sector office.
- Representatives from Rusizi District.
- Cimerwa representatives.
- REMA and/or Ministry of Environment (MoE) representatives, where possible.

Opinions and issues from the stakeholders were recorded and a summary of the issues raised by stakeholders presented as part of Audit findings that required corrective actions.

2.5. Environmental Health and safety (EHS)

Under this EHS section, as part of this Environmental Audit (EA), a general understanding of the EHS status of the Industry was assessed against a list of criteria referred from the 2009 National Environmental Audit (EA) Guidelines (Appendix I) and 2014 Sector specific EA guidelines (Annex A4). The Environmental, Health and safety (EHS) Audit criteria checklist covered the following:

- Environmental protection initiatives.

- Existing environmental Policies and level of compliance.
- Energy management.
- Solid and wastewater management.
- Storm water management.
- Air quality control measures.
- Noise and vibration control measures.
- Occupation health and safety measures.
- Firefighting measures.
- Emergence response and preparedness measures.
- Response to public inquiries and complaints.

2.6. Audit itinerary

The trend of this Audit's Itinerary was as presented in the table below.

Table 14 Audit itinerary

Dates	Activities
4th December 2020	Kick off meeting at Cimerwa PPC factory in Rusizi District, Muganza sector.
14th December 2020	Consultations with Technical staff at Cimerwa Plc factory and factory tour to understand the cement production processes
15th December 2020	Public consultation with chosen representatives of Nyenyeri and Kabarore village, Shara cell office and Muganza sector office on the nature of complaints raised and proposed solutions.
16th December 2020	Consultations with Muganza sector office on the nature of complaints.
4th-9th February 2021	- Ambient pollution monitoring in the neighbourhood of the cement factory and along the road from Amashyuza quarry. - Monitoring of the extent of Noise and vibration levels in the neighbourhood of the factory. - Stormwater sample collection.
26th March 2021	- Monitoring of vibration levels with the Instantel Minimate sensor. - Presentation of the draft EA report to technical staff at Cimerwa Industry in Muganza Sector, Rusizi District.

3 LITERATURE REVIEW

This section covers desk review of literature relevant to the operation and processes of the Cement Industry.
Under this section, legal, regulatory framework and standards relevant to the Industry is discussed. Literature on processes and mass balance of the cement production industry is elaborated.
This section provides secondary data against which the Environmental Audit compared primary results of the analysis of samples collected from field investigations at Cimerwa, in order to determine the Industry's compliance or non- compliance levels and draw corrective actions for non-compliance.

3.1. Relevant legal, regulatory framework and standards referenced.

3.1.1. Policy and legal framework

3.1.1.1. National Environmental and climate change policy 2019

The National Environment and Climate Change Policy (2019) provides strategic direction and responses to the emerging issues and critical challenges in environmental management and climate change adaptation and mitigation.
The policy goal is for "Rwanda to have a clean and healthy environment resilient to climate variability and change that supports a high quality of life for its society."
Seven objectives were established of the policy: (1) Greening economic transformation (2) Enhancing functional natural ecosystems and managing biosafety, (3) Strengthening meteorological and early warning services (4) Promoting climate change adaptation, mitigation and response, (5) Improving environmental well-being for Rwandans, (6) Strengthening environment and climate change governance, (7) Promoting green foreign and domestic direct investment and other capital inflows.
Under the objective 1 to promote a "green economy", one of the policy actions is to strengthen among others, periodic Environmental Audits (EAs) in productive investments, and enforce their implementation (i.e., Environmental Management Plans).
Also, as one of policy's objective 5 to improve environmental well-being for Rwandans, actions were proposed to pay special attention to air pollution and waste generation through emphasis on standardization, effective monitoring and enforcement of laws against all kinds of pollution, hence the purpose of carrying out this Environmental audit.

3.1.1.2. Environmental law

Reference made to the Environmental Law N°48/2018 of 13/08/2018, where in article 15 it stipulates that any installation likely to create risks or cause pollution, vehicles and engine driven machines, commercial, craft or agricultural activities must be conducted in accordance with technical principles established by competent authorities in order to protect and preserve the atmosphere.
Article 32 of the Environmental Law further states that every project that may have significant impact on the environment must undergo an environmental audit (EA) during and after its implementation. Article 33 goes on to state that the EA must be approved by the Authority or another state organ authorized in writing to do so by the Authority (REMA in this case). It is based on this law that Cimerwa Plc commissioned an EA to determine its activities' impact on the environment.

3.1.1.3. Air Quality Law

The Law No 18/2016 governing the preservation of air quality and prevention of air pollution in Rwanda, in article 4, requires the National Authority in charge of establishing quality standards (Rwanda Standards Board in this case) to:

- prescribe criteria and procedure for measuring air quality and air pollutants;
- establish ambient air quality standards in order to curb the impact of air pollutants;
- establish occupational air quality standards for various sources of air pollution which can cause harm to public health'
- establish quality standards that regulate emissions of air pollutants from different sources contributing to air pollution;
- establish specific quality standards that regulate industrial activities with a view to avoid or minimize environmental pollution that may results from such industries;
- determine stack heights of chimneys for air emissions;
- prescribe any matter in relation with or affecting air emissions quality standards.

Article 14 of this law also stipulates that any person whose activity is air polluting and does not comply with the air quality standards must apply for a permit issued by the national Authority in charge of environmental protection (REMA in this case). An order of the Minister determines requirements and modalities for applying, granting and using the permit.

Enforcement of both laws described above required establishment of air quality specifications and emissions standards. Rwanda has adopted the following East African Standards that related to air quality:

- RS EAS 750 2010 - Emissions to the air by cement factories
- RS EAS 751 2010 - Air quality specification
- RS 752 2010 - Tolerance limits of emissions discharged to the air by factories

It is against the background of this law that air quality assessment is included as part of the EA of new Cimerwa plant.

3.1.1.4. Ministerial order No. 001/2021 establishing the list of projects that must undergo Environmental Audits, instructions and procedure for conducting an Environmental Audit.

The Ministerial order no. 001/2021 stipulates instructions on the list of projects that must undergo an Environmental audit (EA) and procedure to be followed in conducting an EA. Among the projects that require an EA are industrial buildings, all works related to the extraction and transformation of quarries, of which Cimerwa industry qualified.

Also, as part of the instructions, the Ministerial order states that an EA is conducted on existing projects or facilities and based on project description or design and baseline information generated during the environmental impact assessment (EIA) process, for those that have EIAs.

Procedure of conducting an EA is such that the developer submits to the Authority a written application which includes a brief description of the project and upon review of the brief, the Authority prepares and submits Terms of Reference (ToR) of the EA to the developer. The Developer may also prepare the ToR and seek approval from the Authority before conducting an EA. The EA is done based on the ToR and done by an Environmental expert from the list of experts published. The EA report is submitted by the developer to the Authority for review and approval, which will accept, reject or request for additional information within 20 days of receipt of the EA report. If it is necessary to hold a Public hearing, the Authority determines an additional period of thirty (30) working days from the date of public hearing notification.

This proposed procedure was followed throughout the Cimerwa EA.

3.1.1.5. Environmental Audit guidelines for Rwanda (2009)

As part of the means to implement the policy and enforce environment law mentioned above, guidelines such as the 2009 Environmental Audit guidelines were developed to guide REMA in making decisions related to the process of periodically assessing implemented projects, programs or organization's activities and services in terms of compliance with relevant statutory and internal requirements, facilitating management control of environmental practices, promoting good environmental management, and maintaining public credibility.

Environmental audit (EA) is a management tool for evaluation of how well Environmental Management Systems (EMS) are performing with the aim of preventing environmental damage; assessing compliance with regulatory requirements; facilitating control of environmental practices by an entity; and placing environmental information in the public domain.

Environmental Audits (EA) operate within the concept of sustainable socio-economic development and enable the achievement of Rwanda's commitments to international environmental conventions such as the Ramsar (1971), Vienna (1985), Montreal (1990), Rio (1992), and Stockholm (2002), the United Nations Framework Convention on Climate Change (1995), the Convention on Substances that Deplete the Ozone Layer(2003), the Kyoto Protocol to the Framework Convention on Climate (2003), all of which Rwanda is a party.

3.1.1.6. Sector specific environmental Audit guidelines for Industry projects (REMA, 2014)

Specific to industries, in 2014, Sector specific environmental Audit (EA) guidelines for Industry projects were developed following the 2009 general Environmental Audit guidelines developed by REMA.

These guidelines are administrative directives meant to guide Environmental Audits of industry projects in Rwanda. They are guidelines that should be used together with any other relevant environmental management instruments developed by REMA, and other relevant laws, regulations and measures that regulate industry activities.

In conducting the sector specific EA guidelines for industry projects, the ultimate aim is to identify and correct environmental concerns that arise with the activities in this particular case, cement production, whether identified or not during the EIA process. They involve evaluating of the impact of industrial activities to the biophysical and socioeconomic environment and to make overall recommendations for improving the operating and environmental conditions and long-term sustainability of those industrial facilities and activities where it is needed, with the goal of establishing if the industry is complying with environmental requirements and enforcing legislation.

As guidance to this Environmental audit, the following procedure is followed.

First of all, the scope of an EA is determined to describe the extent and boundaries of the audit in terms of factors such as: physical location, specific project activities, timing and organizational activities as well as the manner of reporting. The scope of the audit is determined by the client and the lead auditor. The auditee should normally be consulted when determining the scope of the audit. Any subsequent changes to the audit scope need the agreement between the client and the lead auditor. The resources and time committed to the audit should be sufficient to meet its intended scope. The scope of the audit should be finalised at a preliminary meeting with the company (i.e., Client or auditee).

During an EA, Audit criteria is developed as a set of policies, procedures and requirements against which audit evidence is compared and include the provisions within the laws and regulations as set out in the national standards and limits put in place to safeguard the environment.

These sector specific guidelines provide for two categories of environmental audit, namely, control audit and self-audit which are undertaken by the Authority and the proponent, respectively. In the case of this EA, it is a self-audit commissioned by Cimerwa Plc.
Within the two categories, the following types of EA are conducted: (i)EMS audit, (ii) compliance audit, (iii) site property/facility audit, (iv) Environmental assessment audit. Specific to the Cimerwa EA, the type of EA conducted was a compliance audit.
The sector specific EA guidelines further provide for two types of compliance audits: regulatory and performance.
The regulatory compliance Audit evaluate current operations and controls to determine applicable regulatory requirements, resulting in a statement of the compliance status, which was the case for this EA while, the performance Audit determines whether actual environmental management conforms to stated objectives.
To summarise the description of the EA performed under this consultancy, it is a self-audit, conducted as a compliance audit with specific focus on regulatory compliance.
These specific guidelines go on to state that during an EA, an audit plan should include the following: (i)the audit objectives and scope; (ii) the audit criteria; (iii) identification of the proponent's organizational and functional units to be audited; (iv) Identification of the functions and/or individuals within the proponent's organization and their responsibilities, (v)Time frame for audit activities, (vi) Report content and format.
The EA procedure involves three phases: pre-audit activities; on-site activities and post-audit activities.
Pre-audit activities include various preparatory works with focus on knowing the facility to be audited, for instance: the location of the facility with surrounding land uses, climatic conditions, business or activities, raw materials used, details on water utilization, energy utilization, waste generation and disposal, gaseous emissions, organizational set-up and policies of the enterprise or company for environmental management, where applicable.
At this stage, the EA assignment is introduced to the facility, mentioning that the environmental audit should not be considered as a raid but a means of improving environmental management. This introduction to the facility helps the EA team convince the senior management and staff at various levels of the purpose of audit and the cooperation they have to extend to the audit team. To this effect, REMA dispatched one of its staff along with the EA team on the first visit to the Industry.
On site activities involves, designing an audit plan, assigning the Audit team tasks and conducting the audit at the site. Conducting the audit involves; an opening meeting between audit team and management, collecting of audit evidence, audit findings and closing meeting.
Finally, the post audit activities to complete the audit process comprise of; conduct debriefing, developing the audit report and develop an action plan to address audit findings.
The Sector specific EA guideline shared a format of what an Environmental Audit Report (EAR) should contain, listing the contents of the EAR as chapters at least on; (i)Executive summary, (ii)Introduction, (iii)site activity, (iv)audit findings, (v)conclusions and recommendations and Annexes. This format was used in this EA but with adjustment to suit the scope of work required by the client.
The Cimerwa Environmental audit (EA) has applied these sector specific guidelines in the process of carrying out this entire EA.

3.1.1.7. Rwanda National land use planning guidelines (December 2017) and 2019 urban planning code

These guidelines state that industrial development will only be permitted in industrial zones. They further state that all Districts need to adopt uniform national standards for the location and operation of polluting activities. Standards should follow set criteria on the location, buffering and types of industries allowed. The criteria to be adopted for all industrial activities should be restricted to specified 'light', 'commercial' or 'heavy' industry zones. These zones should be defined in the District Development Plan (DDP's) and be determined by the following factors:

- Low risk of pollution runoff to water bodies (dependent on land gradient and distance to water bodies.
- Low risk of landslides.
- Suitable distance from agriculture, residential and flood prone areas.
- Easy road (and rail) access.

Specific to air quality considerations, air quality is affected by such factors as the emission rate of air pollutants, the separation distance between emission sources and receptors, topography, height and width of buildings as well as meteorology.
The guidelines recommend that every planning effort should be made to ensure that:

- Potentially air-polluting industries are not located in areas where the dispersion of air pollutants is inhibited or where the present air pollution is already serious so as to minimize the health hazard to the surrounding residential areas.
- The location of the industrial zones or plants is influenced by the general wind direction; wherever practicable. Industrial zones shall be sited so that urban areas and new towns can take advantage of the prevailing winds.
- High-rise buildings and low-rise air pollution emitters are not located close to each other.
- New traffic generators, especially those of goods vehicles, are not located in areas which currently have severe air pollution.
- Provide adequate buffer distances or screening between specified processes, industries giving rise to dusty, odorous and gaseous emissions, and any sensitive land uses.[3]

The urban planning code published in official gazette no. Special of 16/04/2019, in section 1.7.2, stipulates that there shall be a health protection zone against pollution from industrial uses of between 100 m up to 1,500 m around Special Economic Zone (SEZ's), to be determined by the responsible government agency and depending on the particular use, applicable to the following sub-categories of an SEZ: (i) Heavy industry and power plants, (ii) Agro-industry, and (iii) Light industry and technology.
A summary of recommended buffer distances for land uses in these guidelines corresponding to the 2019 urban planning code are elaborated in the table below. Of specific interest to this audit in the table below, is the buffer distance of industrial chimneys to be at least 500m from sensitive land uses.

[3] Sensitive Land Uses: For the purposes of this guideline, (i.e., where industry is concerned) sensitive land use may include residences, residential areas, day care facilities centres, hospitals and clinics; schools; churches, and other similar institutional uses, or campgrounds and active recreational activities.

Table 15 Summary of buffer distances for land uses recommended by the Rwanda land use planning guide.

Polluting Uses	Sensitive Uses	Buffer Distance
Multi-storey industrial buildings	residential areas, schools	100m
Multi-storey industrial buildings	commercial	30m
Industrial areas	hospitals	500m
Industrial chimneys	sensitive uses	within 500m
Industrial chimneys	high rise buildings	200m
Industrial chimneys	active open spaces	10–50m
Slaughterhouses	sensitive uses and commercial areas	200–300m
Village incinerator	sensitive uses	100m
Odour sources	sensitive uses	200m
Offensive trades	sensitive uses	200m
Dusty uses	sensitive uses	100m
Trunk roads	active open spaces	20m
Trunk roads	residential uses	20–30m

Source: (RLMUA, 2017)

A note was made in this guide stating that to avoid conflicts with adjacent land uses, relevant industry specific standards and guidelines must be determined and developed by the government institution responsible for industries (MINICOM).
Considering that the urban planning code has provision for the health protection zone or buffer zone and the Rwanda land use planning guidelines requires a buffer zone for Industrial chimneys to sensitive uses, it is imperative that Rusizi District, Cimerwa Plc and relevant Central government Institutions consider establishing a buffer zone around the Industry to protect the population against adverse health effects that may arise from emission from Cimerwa.

3.1.1.8. Resource efficient and cleaner production (RECP) investment guidelines for new industries 2017

Relevant to the Environmental performance of the different industries under audit, is the concept of integration of cleaner production technologies and techniques in their operations. The Resource Efficient and Cleaner Production (RECP) investment guidelines for new industries were developed to assist industries in promoting source reduction of wastes and negative impacts on the environment as well as enhancing resource efficiency through the application of cleaner production technologies and techniques.
A model of the typical sequence of implementations of a green industry is presented, which involves; an industry starting with good housekeeping activities, implementing an environmental management system (EMS), using environmentally sound technology and after optimising activities on their premises considering industrial symbiosis options or moving on to eco-innovative products and services.
It is from this guideline that Best Available Techniques (BAT) can be adopted by Cimerwa as remedy to waste generation, pollution reduction and resource efficiency.

3.2. Cement production process, mass balance and emissions

This sub-section discusses the processes followed during cement production, the mass balance with particular emphasis on the inputs and outputs at the main production stage and informs on the likely emissions and relevant parameters for analysis of air, noise and water quality.

3.2.1. Applicable process and techniques in cement

Chemistry of the cement process- The basic chemistry of the cement manufacturing process begins with the decomposition of calcium carbonate ($CaCO_3$), limestone, at about 900°C to calcium oxide (CaO, lime) and liberated gaseous carbon dioxide (CO_2); this process is known as calcination. i.e., $CaCO_3 \longrightarrow CaO + CO_2$

This is followed by the clinkering process in which the calcium oxide reacts at a high temperature (typically 1400–1500°C) with silica (SiO_2), alumina(Al_2O_3), and ferrous oxide (FeO) to form the silicates (Ca_2SiO_4), aluminates ($CaAl_2O_4$), and ferrites ($Ca(FeO_2)_2$) of calcium which comprise the clinker. The clinker is then ground or milled together with gypsum and other additives to produce cement.

Types of Cement manufacture-There are four main process types for the manufacture of cement; the dry, semi-dry, semi-wet and wet processes.

a) The dry process is the type in which the raw materials are ground and dried to raw meal in the form of a flowable powder. The dry raw meal is fed to the preheater or precalciner kiln or, more rarely, to a long dry kiln.
b) The semi-dry process, in which the dry raw meal is pelletised with water and fed into a grate preheater before the kiln or to a long kiln equipped with crosses.
c) The semi-wet process, in which the slurry is first dewatered in filter presses. The resulting filter cake is extruded into pellets and then fed either to a grate preheater or directly to a filter cake dryer for raw meal production.
d) The wet process, in which the raw materials (often with a high moisture content) are ground in water to form a pumpable slurry. The slurry then is either fed directly into the kiln or first to a slurry dryer.

In the case of the new Cimerwa plant, the process type is the dry process and therefore literature and analysis in this Audit focused on the dry process of cement production.

All processes have the following sub-processes in common, which are explained in more detail hereafter as reviewed from (IPPC, 2013):

a) Raw materials–storage and preparation.
b) Fuels–storage and preparation.
c) Use of wastes as raw materials and/or fuels – quality requirements, control and preparation.
d) The kiln systems – kiln firing processes and emissions reduction techniques.
e) Products–storage and preparation.
f) Packaging and dispatch.

A cement process flow diagram is presented in the figure below to demonstrate the stage progress in the manufacturing of cement.

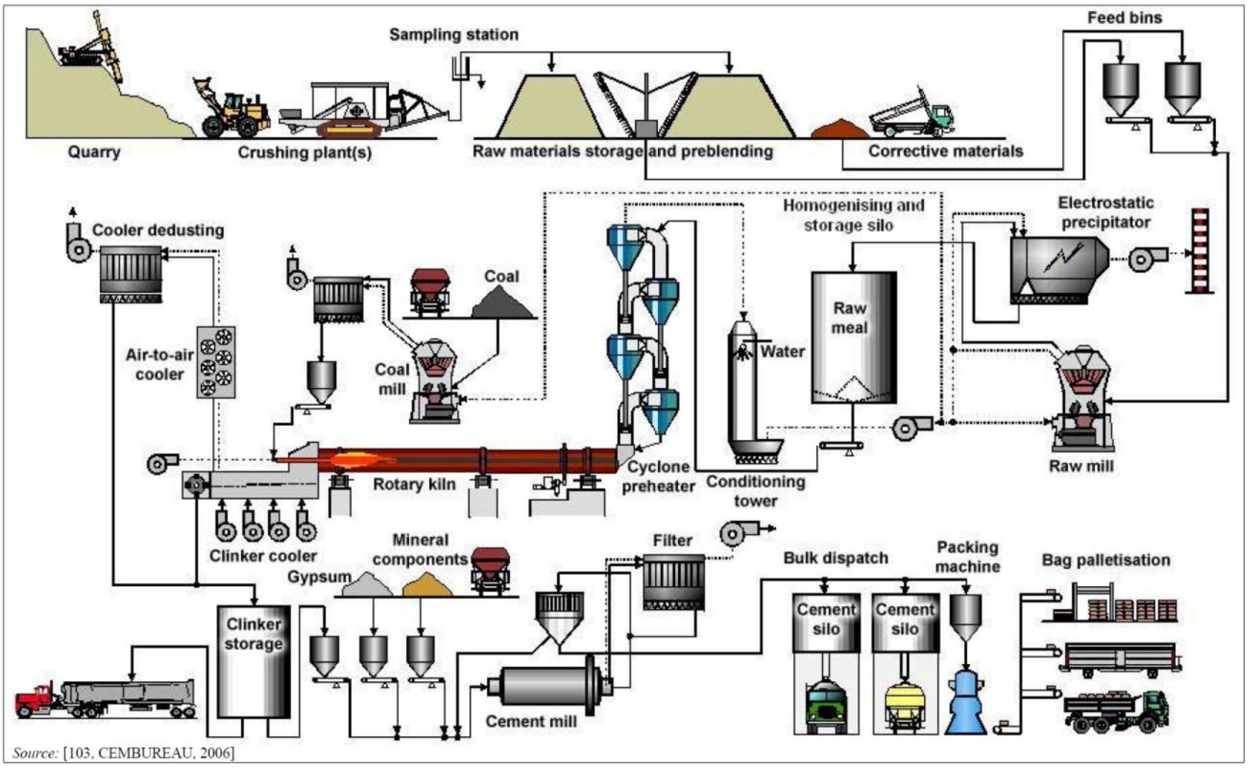

Figure 7: Process flow diagram from a cement plant. Source (CEMBUREAU, 2001).

(a) Raw materials- The main raw materials, which comprise; limestone, chalk, marl and shale or clay, are extracted from quarries. In most cases, the quarry is close to the plant. After primary crushing, the raw materials are transported to the cement plant for storage and further preparation. Other raw materials, such as bauxite, iron ore, blast furnace slag, fly ash or foundry sand, are brought in from elsewhere.
Raw materials have to show characteristics, chemical elements and components that are necessary for the clinker burning process, as these may affect the production process and clinker quality. Table 16 shows example ranges from chemical analyses and characteristics of raw materials and cement raw meals for the production of cement clinker.

Table 16: Chemical analyses of raw materials and cement raw meal for the production of cement clinker

Components	Limestone, lime marl, chalk	Clay	Sand	PFA([1])	Fe source	Raw meal
	(mass %)					
SiO_2	0.5 – 50	33 – 78	80 – 99	40 – 60	0.5 – 30	12 – 16
Al_2O_3	0.1 – 20	7 – 30	0.5 – 7	20 – 30	0.2 – 4	2 – 5
Fe_2O_3	0.2 – 5.9	4.0 – 15	0.0 – 4	5 – 15	50 – 93	1.5 – 2.5
Mn_2O_3	0.02 – 0.15	0.090	0.051	0.127	0.1 – 4	0.0 – 0.5
Fe_2O_3 and Mn_2O_3	0.1 – 10	2 – 15	0.5 – 2		19 – 95	≤ 2
CaO	20 – 55	0.2 – 25	0.1 – 3	2 – 10	0.1 – 34	40 – 45
MgO	0.2 – 6	0.3 – 5	0.3 – 0.5	1.0 – 3	0.5 – 7	0.3 – 5
K_2O	0 – 3.5	0.4 – 5	0.2 – 3	1 – 5	0.1 – 1	0.1 – 1.5
Na_2O	0.0 – 1.5	0.1 – 1.5	0.0 – 1	0.2 – 1.5	0.1 – 1	0.1 – 0.5
SO_3([2])	0.0 – 0.7	0.0 – 4	0.0 – 0.5	0.0 – 1	0 – 3	0 – 1.5
Cl	0.0 – 0.6	0.0 – 1	Traces		0.0 – 0.5	0.0 – 0.3
TiO_2	0.0 – 0.7	0.2 – 1.8	0.0 – 0.5	0.5 – 1.5	0.0 – 3	0.0 – 0.5
P_2O_5	0.0 – 0.8	0.0 – 1.0	0.0 – 0.1	0.5 – 1.5	0.0 – 1	0.0 – 0.8
ZrO_2		0.02				
$CaCO_3$	96					
Loss on ignition ($CO_2 + H_2O$), LOI 950([3])	2 – 44	1 – 20	≤ 5	6.74	0.1 – 30	32 – 36

([1]) Pulverised fly ash.
([2]) Total content of sulphur, expressed as SO_2.
([3]) LOI 950 = loss on ignition.
Source: [60, VDI 2094 Germany, 2003], [81, Castle Cement UK, 2006], [90, Hungary, 2006], [103, CEMBUREAU, 2006]

Source: (CEMBUREAU, 2001)

(b) Raw material storage and preparation-Preparation of the raw materials is of great importance to the subsequent kiln system both in getting the chemistry of the raw feed right and in ensuring that the feed is sufficiently fine. The need to use covered storage depends on climatic conditions and the amount of fines in the raw material leaving the crushing plant.

Source: [81, Castle Cement UK, 2006]

Figure 8: Example of covered raw material storage

The raw material fed to a kiln system needs to be as chemically homogeneous as practicable. This is achieved by controlling the feed into the raw grinding plant (i.e.raw mill). When the material from the quarry varies in quality, initial preblending can be achieved by stacking the material in rows or layers along the length (or around the circumference) of the store and extracting it by taking cross-sections across the pile. When the material from the quarry is fairly homogeneous, simpler stacking and reclaiming systems can be used.

(c) Grinding of raw material- Accurate metering and proportioning of the mill feed components by weight is important for achieving a consistent chemical composition. This is essential for steady kiln operation and a high quality product. Metering and proportioning are also important factors in the energy efficiency of the grinding system. The predominant metering and proportioning equipment for raw material feed to mills is the apron feeder followed by the belt weigh feeder.
For a dry and semi-dry kiln system, grinding of raw materials requires that the raw materials are ground and mixed together in controlled proportions to form a homogeneous blend with the required chemical composition. The raw material components are ground and dried to a fine powder, making use mainly of the kiln exhaust gases and/or cooler exhaust air.
Typical dry grinding systems used are:

- tube mill, centre discharge
- tube mill, airswept
- vertical roller mill
- horizontal roller mill, which is the case for the new Cimerwa factory with a horizontal ball mill.

Ball mills (type of a tube mill) are available in tube diameters of up to 6 m and tube lengths of up to 20 m. Steel balls of different sizes are used depending on the expected grinding fineness.
This type of mill is relatively easy to operate under stable operating conditions and has a high operating reliability and availability. To a limited extent also mineral additions with certain moisture contents can be dried by passing hot gases to the mill and using the heat from the grinding process
The fineness and particle size distribution of the product leaving a raw grinding system is of great importance for the subsequent burning process. The target given for these parameters is achieved by adjusting the separator used for classifying the product leaving the grinding mill.
Raw meal leaving the raw mill grinding process requires further blending/homogenisation to achieve optimum consistency of the raw mix prior to being fed to any type of kiln system. The raw meal is homogenised and stored in silos. For raw meal transport to storage silos, pneumatic and mechanical conveyor systems are used.

(d) Fuels, their storage and preparation- Various fuels (conventional and waste) can be used to provide the heat and the energy required for the process. Different types of conventional fuels are mainly used in cement kiln firing; such as:

- solid fuels, e.g. coal as well as petcoke and lignite, and in some cases oil shale. In the case of Cimerwa, coal imported from Tanzania, local peat and rice husks are the solid fuel used.
- liquid fuels, e.g. fuel oil including highly viscous fuel oil (HVFO).
- gaseous fuels, e.g. natural gas.

The main ash constituents of these fuels are silica and alumina compounds.
Furthermore, ashes may also contain traces of metals. These ashes combine with the raw materials to become part of the clinker. This needs to be allowed for in calculating the raw material proportion and so it is desirable to use fuel with a consistent, though not necessarily low, ash content.

(e) Storage of conventional fuels-Raw coal are stored similarly to raw materials; thus, in many cases, in covered stores. Outside storage in large, compacted stockpiles is used for long term stocks. Such stockpiles may be seeded with grass to prevent rainwater and wind erosion. Drainage to the ground from outside storage has shown to be a problem. However, sealed concrete floors under the stockpiles make it possible to collect and clean the water that drains off. Normal good practice in terms of compaction and stockpile height needs to be observed when storing coal with a relatively high volatile matter content in order to avoid the risk of spontaneous ignition when stored for long periods.

(f) Preparation of fuels- Solid conventional fuel preparation (crushing, grinding and drying) is usually carried out on site. Coal are pulverised to about raw meal fineness in grinding plants using equipment similar to the raw material grinding plants as is the case in the Cimerwa coal mill. The fineness of the pulverised fuel is important, too fine and flame temperatures can be excessively high, too coarse and poor combustion can occur.
Ground solid fuel may be fired directly into the kiln, but in modern installations it is usually stored in silos to allow the use of more thermally efficient burners (indirect firing) using low primary air.
Solid fuel grinding, storage and firing systems have to be designed and operated so as to avoid the risk of explosion or fire. The primary requirements are to control air temperatures properly, and to avoid the accumulation of fine material in dead spots exposed to heat.

(g) use of waste as raw materials-The chemical suitability of wastes used as raw materials is important and they have to provide the constituents required for the production of clinker. As discussed earlier under the chemistry of cement process, the primary desired chemical elements are lime, silica, alumina and iron as well as sulphur, alkalis and others which can be classified into different groups according to their chemical composition.

The use of wastes as raw materials in the clinker burning process involves the substitution of sulphur and the oxides contained in the wastes used as raw materials. These include calcium oxide (CaO), silica (SiO_2), alumina (Al_2O_3) or iron oxide (Fe_2O_3) for the respective raw material constituents. Power station ash (fly ash), blast furnace slag, and other process residues can be used as partial replacements for the natural raw materials. Cimerwa is currently using fly ash from Gishoma and Hakan power plants. Table 17 shows the types of wastes most frequently used as raw materials in the production of cement in Europe.

Table 17: Types of waste frequently used as raw materials in the European cement industry

Fly ash	Blast furnace slag	Silica fume
Iron slag	Paper sludge	Pyrite ash
Spent foundry sand	Soil containing oil	
Artificial gypsum (from flue-gas desulphurisation and phosphoric acid production)		
Source: [8, CEMBUREAU, 2001], [91, CEMBUREAU, 2006]		

Source: (CEMBUREAU, 2001).

Other waste materials are supplied as so-called 'inter-ground' additions to the grinding plants. Fly ash can be used both as raw material in the production of clinker (mainly for its content of alumina) and as an inter-ground addition for cement. Fly ash can replace up to 50% of the Portland cement clinker; however, it may contain mercury. Furthermore, suitable industrial gypsum lends itself for use as a sulphate component. An overview of wastes used as raw materials classified into different groups according to their chemical composition is shown in Table 18.

Table 18: Example list of wastes used as raw materials classified by their chemical composition and used in cement kilns in the EU-25

Raw material group	Examples of wastes used as raw materials
Ca group	Industrial lime (waste limestone) Lime slurries Carbide sludge Sludge from drinking water treatment
Si group	Spent foundry sand Sand
Fe group	Blast furnace and converter slag Pyrite ash Synthetic hematite Red mud
Al group	Industrial sludge
Si-Al-Ca group	Fly ash Slags Crusher fines Soil
S group	Industrial gypsum
F group	CaF_2 Filter sludge
Source: [76, Germany, 2006], [91, CEMBUREAU, 2006], [103, CEMBUREAU, 2006]	

Source: (CEMBUREAU, 2001).

This means that all raw materials and fuel ash must be carefully matched in terms of mineral composition and feed rate to obtain the desired clinker composition.

(h) Clinker burning- This part of the process is the most important in terms of emissions potential and of product quality and cost. In clinker burning, the raw meal is fed to the rotary kiln system where it is dried, preheated, calcined and sintered to produce cement clinker. The clinker is cooled with air and then stored.
In the clinker burning process, high process temperatures are required to convert the raw material mix into cement clinker. It is essential to maintain kiln charge temperatures in the sintering zone of the rotary kilns at between 1400 and 1500°C, and the flame temperature at about 2000°C. The fuel introduced via the main burner produces the main flame with flame temperatures of around 2000°C. Also, the clinker needs to be burned under oxidising conditions, therefore, an excess of air is required in the sintering zone of a cement clinker kiln.

Rotary kilns with Preheaters- Rotary kilns equipped with preheaters have a typical length to diameter ratio of between 10:1and 17:1. There are two types of preheaters: grate preheaters and suspension preheaters. These preheaters allow the rotary kiln to become shorter and so reduce the heat losses and increased energy efficiency.
In the case of the new factory of Cimerwa PPC, the type of preheater installed is the suspension preheater.
Suspension preheaters usually have between four and six cyclone stages, which are arranged one above the other in a tower 50–120 m high. Cimerwa has a five cyclone stage. The uppermost stage may comprise two parallel cyclones for better dust separation. The exhaust gases from the rotary kiln flow through the cyclone stages from the bottom upwards. The dry powdery raw material mixture is added to the exhaust gas before the uppermost cyclone stage. It is separated from the gas in the cyclones and rejoins it before the next cyclone stage. This procedure repeats itself at every stage until finally the material is discharged from the last stage into the rotary kiln. This alternate mixing, separation and remixing at a higher temperature is necessary for optimal heat transfer.

When the Raw meal enters the rotary kiln, calcination is already about 30% completed because the kiln feed is already heated in the pre-heaters to a temperature of approx. 850°C by using the exhaust gases.

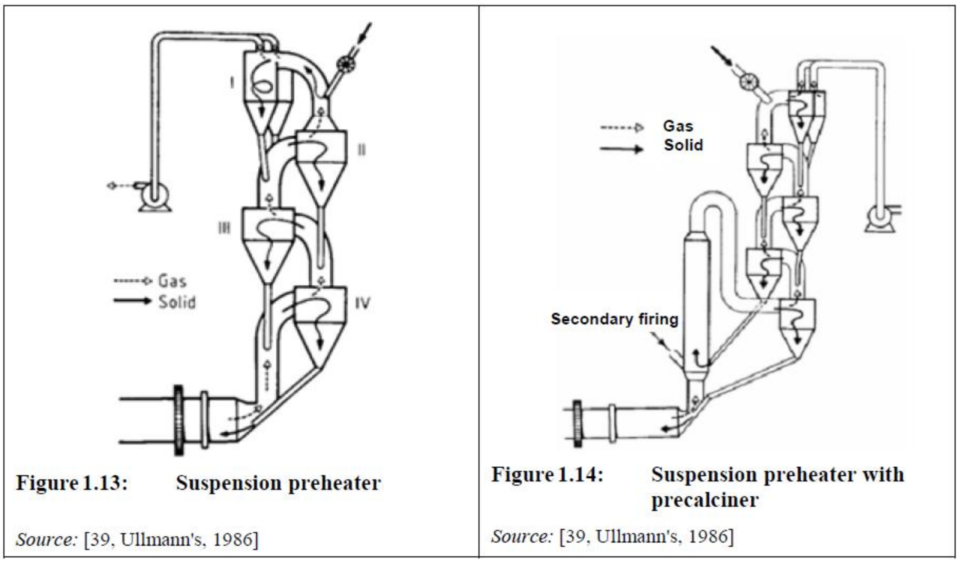

Figure 9: Suspension preheaters. Source: (IPPC, 2013)

Kiln exhaust gases- In all kiln systems, the exhaust gases are finally passed through an air pollution control device (electrostatic precipitator or fabric filter) for separation of the dust before going to the main stack.

(i) Clinker coolers-The clinker cooler is an integral part of the kiln system and has a decisive influence on performance and economy of the pyroprocessing plant. The cooler has two tasks: to recover as much heat as possible from the hot (1450°C) clinker so as to return it to the process; and to reduce the clinker temperature to a level suitable for the equipment downstream. There are two main types of coolers: rotary and grate. In the case of Cimerwa, the rotary cooler is of interest.
The Rotary tube cooler uses the same principle as the rotary kiln, but for reversed heat exchange.

(j) Clinker storage and cement storage- Clinker and other cement components are stored in silos or in closed sheds.

(k) Cement grinding- Portland cement is produced by intergrinding cement clinker with sulphates such as gypsum and anhydrite. In blended cements (composite cements) there are other constituents, such as granulated blast furnace slag, fly ash, natural or artificial pozzolanas and limestone, or inert fillers. These will be interground with the clinker or may need to be dried and ground separately. Grinding plants may be at separate locations from clinker production plants.
Most mills work in a closed circuit, where they can separate cement with the required fineness from the material being ground and return coarse material to the mill.

(l) Storage of cement- Both pneumatic and mechanical conveying systems can be used for transporting cement to storage silos. Mechanical systems normally have a higher investment cost but a much lower operating cost than pneumatic transport. A combination of air-slide or screw/chain conveyors with a chain bucket elevator is the most commonly used conveying system.
Compressed air is used to initiate and maintain the cement discharge process from these silos via aeration pads located at the bottom of the silo.

(m) Packaging and dispatch- Cement is transferred from the silos either directly into bulk road, rail or ship tankers, or to a bag packaging station.

3.2.2. Mass balance and emission levels in cement production

According to the (IPPC, 2013), the main environmental issues associated with cement production are emissions to air and energy use. Waste water discharge is usually limited to surface run off and cooling water only and causes no substantial contribution to water pollution. The storage and handling of fuels is a potential source of contamination of soil and groundwater.

The purpose of a mass balance is to evaluate the mass components entering and exiting the system, taking into account the law of mass conservation. For purposes of demonstration, the Audit used this mass balance for the production of 1 kg of cement using the dry process with petcoke as the fuel is shown in Figure 10 below, from (IPPC, 2013). Even though Cimerwa uses Coal as fuel, a roller cooler and a ball mill, the mass balance is indicative of inputs and outs during cement prodcution.

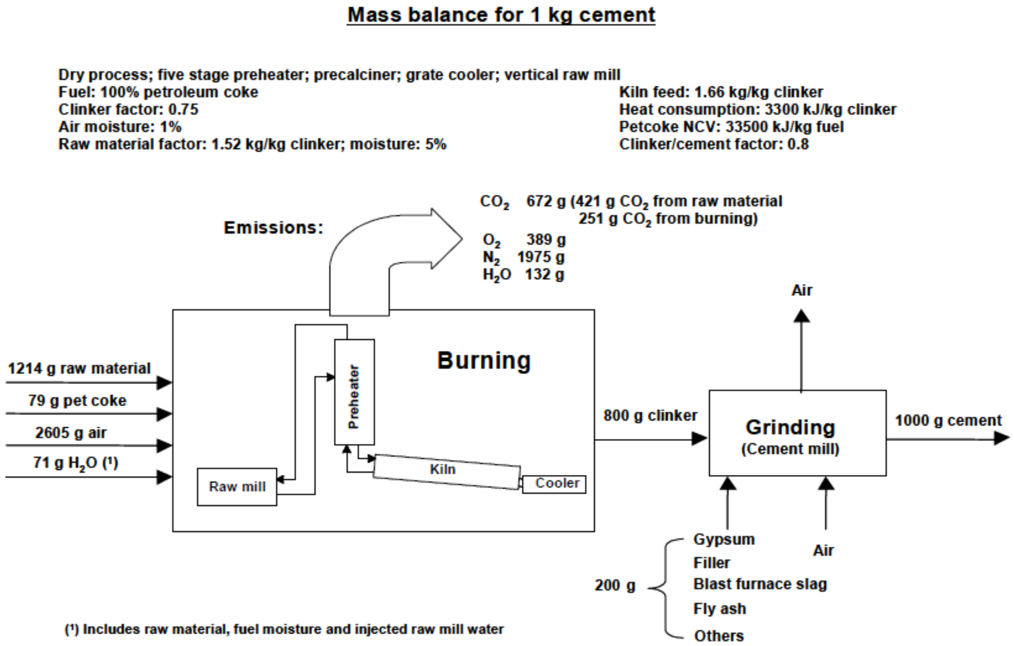

Figure 10:Mass balance for the production of 1 kg cement using the dry process. Source: (IPPC, 2013)

Emissions to air

The main constituents of the exit gases from a cement kiln are nitrogen from the combustion air; CO_2 from calcination of $CaCO_3$ and combustion of fuel; water vapour from the combustion process and from the raw materials; and excess oxygen.

The emissions ranges within which kilns operate depend largely on the nature of the raw materials; the fuels; the age and design of the plant; and also on the requirements laid down by the permitting authority. For example, the concentration of impurities and the behaviour of the limestone during firing/calcination can influence emissions, e.g. the variation of the sulphur content in the raw material plays an important role and has an effect on the range of the sulphur emissions in the exhaust gas.

Table 19: Data of emissions ranges from European cement kilns

Reported emissions from European cement kilns(1)			
Pollutant	**mg/Nm^3**	**kg/tonne clinker**	**tonnes/year**
NO_x (as NO_2)	145 – 2 040	0.33 – 4.67	334 – 4 670
SO_2	Up to 4 837(2)	Up to 11.12	Up to 11 125
Dust	0.27 – 227(3)	0.00062 – 0.5221	0.62 – 522
CO	200 – 2 000(4)	0.46 – 4.6	460 – 11 500
CO_2	-	Approx. 672 g/t_{cement}	1.5456 million
TOC/VOC	1 – 60(5)	0.0023 – 0.138	2.17 – 267
HF	0.009 – 1.0	0.021 – 2.3 g/t	0.21 – 23.0
HCl	0.02 – 20.0	0.046 – 46 g/t	0.046 – 46
PCDD/F	0.000012 – 0.27 ng I-TEQ/Nm^3	0.0276 – 627 ng/t	0.0000276 – 0.627 g/year
Metals(6)			
Hg	0 – 0.03(7)	0 – 69 mg/t	0 – 1 311 kg/year
∑ (Cd, Tl)	0 – 0.68	0 – 1 564 mg/t	0 – 1 564 kg/year
∑ (As, Sb, Pb, Cr, Co, Cu, Mn, Ni, V)	0 – 4.0	0 – 9 200 mg/t	0 – 9 200 kg/year

(1) Mass figures are based on 2 300 m^3/tonne clinker and one million tonnes clinker per year. Emissions ranges are yearly averages and are indicative values based on various measurement techniques. The reference O_2 content is normally 10 %.
(2) Values from SO_2 measurements in the clean gas of 253 rotary kilns. 11 measurements are above the scale. Of these, 7 are of '0' substitution rate, 3 are '0 – 10', and one is 'above 40'. High SO_2 emissions are to be expected when the raw materials contain volatile sulphur compounds (e.g. Pyrite). Indeed, these oxidisable compounds may be converted to SO_2 as early as in the upper cyclone stages. This SO_2 can be captured in the raw mill by the finely ground raw material.
(3) The figures are values from continuous dust measurements in the clean gas of 253 rotary kilns. 8 measurements are above the scale. The emission levels largely depend on the state of the abatement equipment.
(4) In some cases, CO emissions can be higher than 2 000 mg/Nm^3 and up to 5 000 mg/Nm^3 (11.5 kg/tonne clinker), e.g. Due to NO_x reduction.
(5) Yearly average values from 120 measurements; only a few values range above 60 mg/Nm^3 (up to 122.6 mg/Nm^3 or 0.28 kg/tonne clinker).
(6) '0' implies LOD = level of detection.
(7) Collected from 306 spot measurements with an average value of 0.02 mg/Nm^3 and an upper value of 0.57 mg/Nm^3 (1 311 mg/tonne clinker).

Source: (IPPC, 2013).

Typical kiln exhaust gas volumes expressed as m^3/tonne of clinker (dry gas, 101.3 kPa, 273 K) are between 1700 and 2500 for all types of kilns (CEMBUREAU, 2001). Suspension preheater and precalciner kiln systems normally have exhaust gas volumes of around 2300m^3/tonne of clinker (dry gas, 101.3 kPa, 273 K).
There are also channelled emissions of dust from other sources, such as grinding (milling) and handling operations, raw materials, solid fuel and product.
There is a potential for the diffuse emissions of dust from any outside storage of raw materials and solid fuels as well as from any materials transport systems, including cement product loading. The magnitude of these emissions can be significant if these aspects are not well engineered or maintained and being released at a low level can lead to local nuisance problems.

Dust(Particulate matter)

Chanelled dust emissions- Traditionally, the emissions of dust (PM), particularly from kiln stacks, have been one of the main environmental concerns in relation to cement manufacture. The main sources of dust emissions are the raw material preparation process (raw mills), grinding and drying units, the clinker burning process (kilns and clinker coolers), the fuel preparation and cement grinding unit (mills). Subsidiary processes of a cement plant lead to dust emissions, independent of whether waste is used or not, such as:

- crushing of raw materials,
- raw material conveyors and elevators,
- storage for raw materials and cement,
- grinding mills for raw materials, cement and coal,
- storage of fuels (petcoke, hard coal, lignite) and
- dispatch of cement (loading).

As a mitigation measure to likely impacts of channelled dust emission, the design and reliability of modern electrostatic precipitators or fabric filters ensure dust emissions can be reduced to levels where they cease to be significant; emission levels of below 10 mg/Nm^3 (daily average values) are achieved in 37% of the reported installations.

Table 20: Examples of dust reduction techniques along with reduction efficiencies according to the RAINS model

Technique	Reduction efficiency (%)		
	Total particulate matter	PM_{10}	$PM_{2.5}$
Cyclone	74.4	52.86	30
ESP 1	95.8	94.14	93
ESP 2	98.982	97.71	96
ESP 3	99.767	99.51	99
Fabric filter	99.784	99.51	99
Wet scrubber	98.982	97.71	96

Source: (IPPC, 2013).

Kiln dust can directly be re-used within the process of cement manufacturing or can be used for other purposes.

Diffuse dust emissions- Diffuse dust emissions can arise during the storage and handling of materials and solid fuels, e.g. from open storage, conveyors of raw materials, and also from road surfaces because of road transport. Dust arising from packaging and dispatch of clinker/cement can also be significant. The impact of diffuse emissions can be a local increase in levels of dust, whereas process dust emissions (generally from high stacks) can have an impact on the air quality over a much larger area.

According to the (IPPC, 2013), to minimise diffuse dust emissions, mitigation measures proposed comprise of; constructing conveyors and elevators as closed systems, if dust emissions are likely to be released from dusty material. Roads used by lorries are paved and cleaned periodically in order to avoid diffuse dust emissions. In addition, spraying with water at the installation site is used to avoid these emissions. Wherever possible, closed storage systems are used.

Nitrogen oxides (NOx)

The clinker burning process is a high temperature process resulting in the formation of nitrogen oxides (NOx). These oxides are of major significance with respect to air pollution from cement manufacturing plants. They are formed during the combustion process either by a combination of fuel nitrogen with oxygen within the flame or by a combination of atmospheric nitrogen and oxygen in the combustion air. There are two main sources for the production of NOx: thermal NOx and fuel NOx. Since for Cimerwa no fuel nitrogen is applied, the focus was on thermal NOx. Thermal NOx is formed when part of the nitrogen in the combustion air reacts with oxygen to form various oxides of nitrogen. Thermal NOx forms at temperatures above 1050ºC. The amount of thermal NOx produced in the burning zone is related to both burning zone temperature and oxygen content (air excess factor). The rate of reaction for thermal NOx increases with temperature; therefore, hard-to-burn mixes which require hotter burning zones will tend to generate more thermal NOx than kilns with easier burning mixes. The rate of reaction also increases with increasing oxygen content (air excess factor). Running the same kiln with a higher back-end oxygen content (air excess factor) will result in a higher thermal NOx generation in the burning zone (although emissions of SO_2 and/or CO may decrease).

While fuel NOx form when compounds containing nitrogen, chemically bound in the fuel, react with oxygen in the air to form various oxides of nitrogen.
NO and NO_2 are the dominant nitrogen oxides in cement kiln exhaust gases.

Sulphur dioxides (SO_2)

SO_2 emissions from cement plants depend on the total input of sulphur compounds and the type of process used, and are primarily determined by the content of the volatile sulphur in the raw materials and possibly by the fuels. Elevated SO_2 emissions are to be expected when raw materials containing organic sulphur, and in particular when raw material-borne sulphur is present in a readily oxidisable form, e.g. as pyrite or marcasite.
However, kilns that use raw materials with little or no volatile sulphur have few problems with SO_2 emissions and emissions concentrations in the flue-gas are below 10 mg/Nm^3 without abatement at some kilns, the SO_2 emissions concentration increases with increased levels of volatile sulphur in the used raw material.
In contrast to the calcining area, 40 to 85% of the SO_2 formed is recaptured in the preheater.

Carbon oxides (CO_2, CO)

CO_2-The emissions of CO_2 are estimated to be 900 to 1000 kg/tonne grey clinker, related to a specific heat demand of approximately 3,500 to 5000 MJ/tonne clinker, but this also depends on fuel type. Due to cement grinding with mineral additions, the emissions of CO_2 are reduced when related to tonnes of cement. Approximately 62% originates in the calcining process and the remaining 38% is related to fuel combustion. Emissions of combustion CO_2 have progressively reduced, with a reduction of about 30% in the last 25 years being accomplished mainly by the adoption of more fuel efficient kiln processes.
CO- The emissions of CO and organically bound carbon during the clinker burning process are caused normally by the small quantities of organic constituents input via the natural raw materials (remnants of organisms and plants incorporated in the rock in the course of geological history). These are converted during kiln feed preheating and become oxidised to form CO and CO_2.
Depending on the raw material deposit, between 1.5 and 6 g of organic carbon per kg clinker are brought into the process with the natural raw material. Tests using raw meals of various origins showed that between 85–95% of the organic compounds in the raw material are converted to CO_2 in the presence of 3% oxygen, but at the same time 5–15% are converted to CO. The proportion emitted as volatile organic carbon compounds (VOC) under these conditions is well below 1%.

Metals and their compounds

Raw materials and fuels will always contain metals. Their concentrations vary widely from one location to another and the potential for emissions to the atmosphere is affected by very complex mechanisms.
Metals which are or have compounds that are refractory or non-volatile, such as Ba, Be, Cr, As, Ni, V, Al, Ti, Ca, Fe, Mn, Cu and Ag. These metals are completely absorbed by the clinker and discharged with it, and therefore do not circulate in the kiln system. In the exhaust gas, the only emissions are with the dust; they depend only on the input and the efficiency of dust segregation. Consequently, emissions are generally very low.

Emission to water

In general, cement production does not generate effluent. In cement production using the dry or the semi-dry process, water is only used in small quantities, e.g. for cleaning processes. In principle, no emissions to water occur because water is recycled back into the process.

Noise

Noise emissions occur throughout the whole cement manufacturing process from preparing and processing raw materials, from the clinker burning and cement production process, from material storage as well as from the dispatch and shipping of the final products. The heavy machinery and large fans used in various parts of the cement manufacturing process can give rise to noise and/or vibration emissions, particularly from:

- chutes and hoppers
- any operations involving fracture, crushing, milling and screening of raw material, fuels,
- clinker and cement
- exhaust fans
- blowers
- duct vibration.

Plants are required to comply with reduction standards in compliance with national legislation, and noise surveys should be conducted and evaluated. Natural noise barriers, such as office buildings, walls, trees or bushes are used in the cement industry to reduce noise emissions. Where residential areas are located close to a plant, the planning of new buildings at the cement site is connected with a necessity to reduce noise emissions.

Monitoring of parameters and emissions

According to the (IPPC, 2013), to control kiln processes, continuous measurements are recommended for the following parameters:

- pressure
- temperature
- O_2 content
- NOx
- CO, and possibly when the SOx concentration is high
- SO_2 (it is a developing technique to optimise CO with NOx and SO_2).

Regular periodic monitoring is appropriately carried out for the following substances:

- metals and their compounds
- TOC
- HCl
- HF
- NH_3, and
- PCDD/F.

In regard to the scope of this Environmental Audit, emissions monitored at the stacks were restricted to dust. Cimerwa Plc might need to perform regular perodic monitoring for the other substances mentioned above.

3.3. Propagation and distribution of dust, noise and vibration around their sources

3.3.1. Dust or Particulate Matter

The dust emission from factory fall in the particulate matter or aerosol category of air pollutants. Atmospheric aerosol are generally considered to be the particles that range in size from a few nanometers (μm) to tens of micrometers in diameter. Most attention has been focused on "$PM_{2.5}$" of "fine PM" which designates the fraction with aerodynamic diameters smaller than 2.5 μm because of their effects on health and visibility. These fine particles can easily enter the lungs owing to their small diameter. Because of their small size $PM_{2.5}$ stay in air for long time (days to weeks) and can be carried by wind to great distances (across cities). Another category of regulated particulate matter is "PM_{10}" which are particles with an aerodynamic diameter less than 10 μm also called coarse particles. These particles have a much shorter lifetime in air (order of hours) because they quickly settle to the ground by gravity. Both $PM_{2.5}$ and $PM_{10.}$ are removed by rain. Their impact will depend largely on the wind speed and direction, and topography[4].

3.3.2. Noise propagation

The sound intensity, which is defined as the sound power per unit area, from a point of sound will obey the inverse square law if there are no reflections of reverberation. The basic unit of the sound intensity is watts/m^2. In practice, sound intensity measurements are made relative to a standard threshold of hearing intensity I_0:

$$I_0 = 10^{-12}\, watts/m^2$$

The most common approach to sound intensity measurement is to use the decibel scale:

$$I(dB) = 10 \log_{10} \left[\frac{I}{I_0}\right]$$

If a sound intensity I_1 is measured at a distance d_1 from a source, the sound intensity I_2 at a distance d_2 will be estimated using the following formula:

$$\frac{I_2}{I_1} = \left[\frac{d_1}{d_2}\right]^2$$

For example, if a sound level of 90 dB is measured at a distance of 6 m outside the cement factory of CIMERWA, the calculation above would predict a sound level of 56.0 dB at an unobstructed distance of 300 m from the cement mill[5].

3.3.3. Vibration propagation

Vibration intensity decreases with distance approximately following the inverse square law ("$1/r^2$"); this part of the decrease in vibration wave intensity with distance is often referred to as "geometric damping". In addition to geometric damping, different types of soil will cause lesser or greater loss in the vibration intensity. Such damping is called "material damping". Empirical estimation of vibration velocities (PPV) exist, including the one offered by the United States Federal Transit Administation's (FTA) Noise and Vibration Manual((Hanson, et al., 2012)

$$PPV = PPV_{ref}\ x \left(\frac{25}{D}\right)^{1.5}$$

Where PPV is the calculated peak particle velocity in units of in/sec of a specific machine at the distance of interest D. PPVref is the reference vibration level for that type of machine at a reference distance of 7.6 m.

An example of application of the FTA formula to assess the impact of a compactor at various distance (in feet) is provided in figure 11; It indicates that the PPV decreases from 2.5 in/sec to 0.2 in/sec within 50 ft (15m) this is a decrease of 92%. In summary, unlike dust and noise which can go to great distances (hundreds of meters), vibration is dumpened quickly in first few meters near the source.

[4] https://www.nap.edu/read/12743/chapter/5

[5] http://hyperphysics.phy-astr.gsu.edu/hbase/Acoustic/isprob2.html

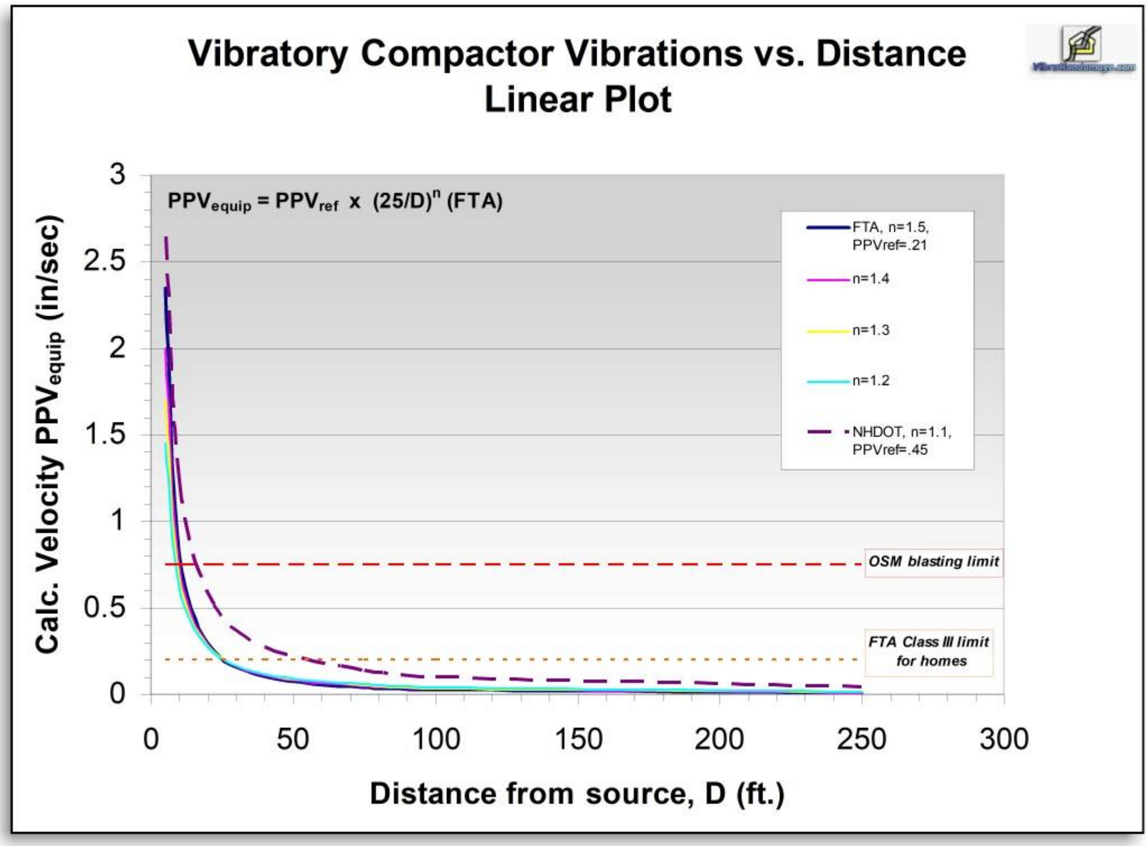

Figure 11: Calculation of vibration from a compact versus distance[6]

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[6] https://vibrationdamage.com/compdislinlg.jpg

4 DESCRIPTION OF THE CASE STUDY FOR CIMERWA FACTORY

4.1. New Cimerwa factory production process

4.1.1. Introduction

CIMERWA Plc is a cement manufacturing factory that has existed in Rwanda for over 36 years, since 1984, with the company shares owned by PPC International Holdings (PTY) Ltd 51% shareholding, AGDF Corporate Trust Ltd 16.55%, Rwanda Social Security Board 20.24%, Rwanda Investment Group 11.45% and Sonarwa Holdings Ltd 0.76%.
It is located in Rusizi District, Muganza sector, Shara cell, Nyenyeri and Kabarore villages and surrounded mostly by residential communities from the two villages mentioned above and shown in the area layout below.

Figure 12: Cimerwa factory and its surrounding communities

The quarry that supplies limestone to CIMERWA is located at 3 km to the North, at the location of Amashyuza hot springs. Also, along the unpaved road to Amashyuza quarry, within 1 km upslope of the road, are human settlements. Key vulnerable receptors of air pollution along the road are Mashesha health center located at about 600 m from the road and Mashesha primary school located at 1 km from the road. The highest population density along the road is located near the health center and the school.

Further to the east of Cimerwa is the Bugarama wetland used for agriculture, mostly rice cultivation and served by the Rubyiro river.

4.1.2. Cimerwa production process

According the 2009 Cimerwa Environmental Social Management Plan (ESMP), the old CIMERWA plant produced about 70,000 Tonnes per annum(tpa) of clinker equivalent to 100,000 tonnes of cement per annum using the wet process of cement manufacture. During consultations with Cimerwa technical staff at the new factory, the Auditors were informed that the old Cimerwa factory had been closed in 2014 and the new factory opened in 2015. The new factory targetted production of 600,000 tonnes per annum of cement. Currently, the new factory is producing about 1200Tonnes per day of clinker commensurate to 2,200Tonnes per day of cement. The old factory used a wet cement production system that had the Elecrostatic Preciptators (ESP) to trap dust emission while the new factory currently uses a dry cement production that has bag house filters(BFs) to trap dust emission.

Since the scope of this EA was the new factory and not the old factory, the Audit focused on understanding the processes involved only in the dry process of cement production at the new factory of Cimerwa.

As explained by the technical staff, at Cimerwa, the main raw materials applied in cement production are; Limestone, Sandstone, clay and pozzolana(volcanic rock). To make cement, 4 major elements have to be in balance and these are; CaO from Limestone, SiO_2 from sandstone, Fe_2O_3 and Al_2O_3 from clay. Cimerwa is currently replacing clay with pozzolana due to a higher moisture content in clay that requires more energy to dry and burn. Minor elements also required in material for cement production are: potassium oxide (K_2O), Sodium Oxide (Na_2O), Chloride (Cl), Sulphides (SO_3), Magnesium oxide(MgO).

The process flow for cement production is demonstrated in the figure below and elaborated hereafter as explained by Cimerwa.

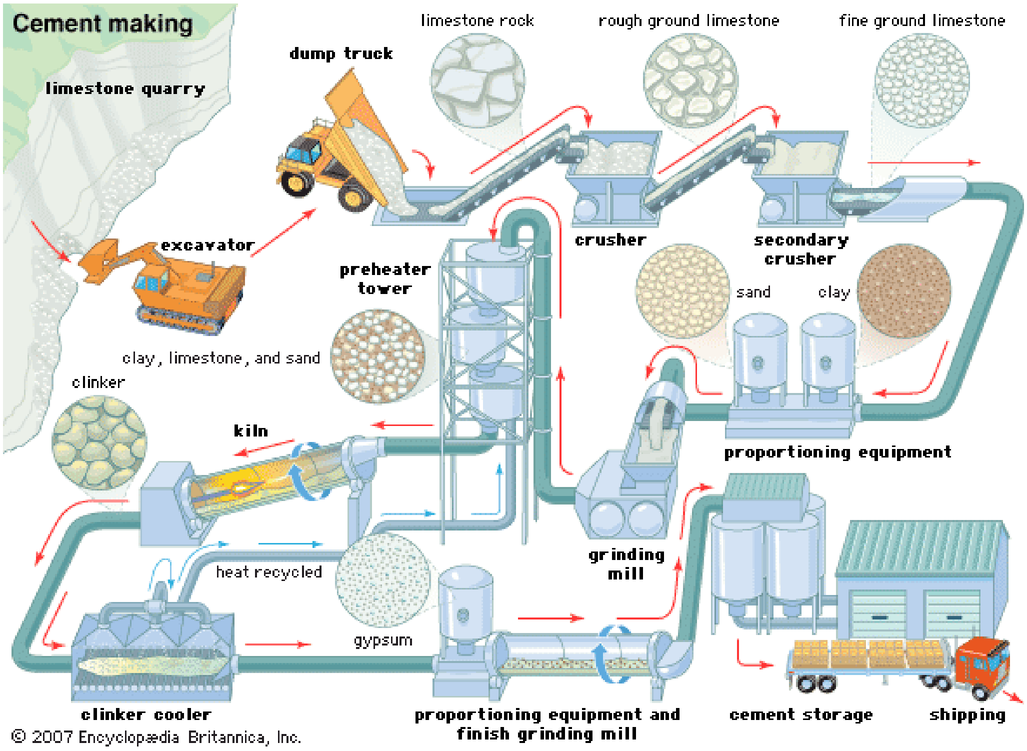


Figure 13:Process flow for Cement production. Source: CivilDigital.com

a) Stockpiling- Limestone, sandstone and pozzolana from the quarries are stored as stock piles under sheds at the New Cimerwa factory at locations close to the Nyenyeri village side. The moisture content for the raw material required for cement production ranges from; 12-16% for limestone, 4-7% for sandstone, 8-12% Pozzolana. Imported Coal from Tanzania used as a fuel for burning in the kiln in making clinker is also stored in a separate shed at the New factory at a location closer to the Kabarore village and the other bulk of coal stored at an open area on the old factory premises. Other fuels used are peat, stored behind the new factory premises covered by tarpulins and rice husks under a shed on the old factory premises.

Covered crushed raw material shed.

Uncrushed raw material shed.

Sandstone crusher at factory entrance closer to Kabarore village

b) Crushing phase- Limestock rock and sandstone are crushed separately into fine ground limestone and sandstone. The ground sandstone and clay or in this case pozzolana at Cimerwa, is then mixed with ground limestone by the proportioning equipment to balance the proportions of major oxides as required for the final cement product (i.e.CaO, SiO_2, Fe_2O_3 and Al_2O_3). Ground mix is screened to only allow a fine mix of at most 25mm size for the next stage and the residue sent back to the crusher.

c) Raw Mill grinding stage- At the Ball mill, balls are used to grind the 25mm into a finer powder of about 80um. This product is called the raw meal, which is sent to the homogenising raw meal silo for about 2 days.

Ball mill

Raw meal from ball mill

d) Pre-heating- the homogenised raw meal from the silos is then sent for pre-heating, where it is pre-heated by hot air through five stage cyclones preheater towers at 800°C and where the calcination occurs.i.e. $CaCO_3 \rightarrow CaO + CO_2$. This pre-heating process helps minimise the amount of NOx gas that could be generated at the next stage of the kiln, if it had to heat the raw meal by itself from initial temperature and raise temperature above 1400°C. It is also important in reducing the amount of energy required for heating in the Kiln, allowing the kiln to pick up from 800°C temperature and therefore cuts cost of coal used for burning in the kiln.

e) Kiln stage- At the kiln, coal is the main fuel used to burn the pre-heated raw meal at a temperature of 1500°C to produce Clinker. Clinker is then cooled at the cooler from 1500°C to 250°C, giving off hot air recycled for re-use at the pre-heater cyclones of the previous pre-heating stage. Cooled clinker is stored in silos. Cimerwa is currently using locally available alternative fuels to minimise use of coal, such as; peat, rice husks and palm kennel. The target is to have about 19% use of alternative fuels replacing coal use but are currently at 13%.


Rotary kiln


clinker

f) Stack emission treatment- The new factory currently uses Bag house filters (BF) for treatment of dust emissions before discharging flue gas through the chimneys. The BFs have been installed mainly at the kiln, clinker coolers and mills(raw mill, cement and coal mill). The type of fibre used in these BFs is glass fibre woven.

g) Blended Portland Pozzolana Cement final product stage- To produce the final cement product, gypsum and pozzolana are added in measured proportion to the clinker and ground at the ball cement grind miller to produce the final cement product. The addition of these fillers reduces on the amount of clinker for final cement production without compromising its quality and therefore reduces the carbon footprint of making cement. The purpose of gypsum is to retard the reaction time for cement setting, while the pozzolana improves the laying strength at day 2, 7 and 28. The cement powder is sent to cement silo for storage.


Packing in 50kg bags


Packing area with cement dust on floor

h) Packing stage- Cement is packed in 50kg bags or in bulk mobile tanks ready for distribution to consumers.

i) Quality Assurance (QA)- Samples are taken for quality assurance testing at each of these stages mentioned above.(i.e. sample for the raw material at the quarry and stock pile, sample from crushed mix, sample of the raw meal, sample of the coal used for kiln, sample of the clinker and sample of the blended portland pozzolana cement). QA laboratories test the major and minor elements to the required proportions.

4.1.3. Findings and recommended actions from previous correspondences towards the New Cimerwa factory

An Environmental Impact Assessment (EIA) certificate was issued by RDB for the construction of the new cement plant of Cimerwa Plc on the 31^{st} December 2009 based on the 2009 Cimerwa Environmental Social Management Plan (ESMP) ((RSB), 2019). Among the requirements for implementation during the operation phase of the new cement plant as recorded in the conditions of approval of the EIA certificate, particularly relevant to the scope of this Audit were:

- To have a wastewater treatment plant for the main office building and consider having either a maintenance contract with a supplier or recruit a technician to handle its maintenance.
- To sort/ segregate waste at the source, reuse and dispose of non-reusable solid waste and sludge to the appropriate landfill, in which case a solid waste disposal company would be contracted for the later purpose.
- Conduct an Environmental Audit annually with focus on the following aspects; emissions to air, noise, occupation health and safety.
- Ensure fire-fighting measures are well established at the new plant.
- Conduct regular trainings of staff on disaster management to avert potential disasters.
- Recruit permanently and employ an Environmental staff to ensure the plant's compliance to environmental requirements.
- To ensure secure measures are taken in storage and handling of peat used as a source of energy to avoid any danger to the workers and neighbouring communities.

Complaints had been raised by residents of the neighbouring communities of Nyenyeri and Kabarore village, of adverse impacts supposedly emerging from the activities of the new factory and its close proximity to these communities. As mentioned in previous sub-chapters 1.4 and 1.5 of challenges related to the factory activities towards the surroundings and relevance of the Audit, the complaints raised rotated around the following aspects:

- Loud noise from the new industry operations.
- Cement and coal dust from the new industry polluting their food, rainwater harvested, their homes, settling on their roofs and trees, causing them eye infections and respiratory distress.
- High levels of vibration resulting in the cracking of house walls and for some houses collapsing.
- Storm water from the new industry causing flooding of some houses and destroying some houses in Nyenyeri village community.

Correspondences related to these complaints and interim propositions on how to address these complaints between the affected communities, Cimerwa Plc and relevant authorities are presented here for better understanding of the trend of the situation:

- On the 3rd July 2020, Muganza Sector responded to complaints by Nyenyeri village and Kabarore village of the effects of the new Cimerwa factory activities by inspecting the villages to verify their complaints. From inspection of houses for those that claimed to collapse from vibrations, Sector officials mentioned that some had collapsed due to poor construction material. However, the Sector recommended that;
    - Cimerwa supports the homes by building the collapsed houses and
    - REMA and RHA be requested to support in performing noise, vibration, dust levels monitoring and the location of the village compared to the industry in order to determine impact on the villages.
    - To this effect, the sector sent a letter to Rusizi District requesting for assistance in engaging REMA and RHA on responding to the effects of vibrations.
- On the 6th July 2020, a letter was submitted to the Ministry of Environment (MoE) by Nyenyeri village community with the same complaints requesting for redress.
- On the 6th August 2020, MoE responded with a letter to Cimerwa to address the following issues raised:
    - Issues of noise, vibration, dust and storm water arising from the close proximity of settlements to Cimerwa,

    - Requesting Cimerwa to present a lasting solution to complaints raised,
    - To submit a plan to solve these issues within 15days of receipt of the letter,
    - To install continuous ambient air quality monitoring systems at the factory boundaries.
    - Submit to REMA and MoE results of air quality measurements taken.
- On the 28th August 2020, Cimerwa responded to the MoE letter, based on the issues discussed in the meeting Cimerwa held with MoE on the 25th August 2020, with the following propositions:
    - To minimise dust pollution, the first Bag house filters to trap dust would be delivered and installed by 30th September 2020 and the rest in October 2020.
    - Ambient continuous air quality monitors would be installed in November 2020 from a supplied in South Africa.
    - Stack Continuous monitors of Isokimetic equipment would be installed by September 2020.
    - Regarding issues raised of noise, vibrations and storm water, an Environmental Audit would be commissioned in order to guide Cimerwa and relevant authorities on decisions to be taken.
- On the 27th August 2020, 28 Kabarore village members through their lawyer sent a letter to Cimerwa informing them that they had filed a case requesting for compensation of damages caused by vibrations, noise and dust from the new factory. The compensation required was an expropriation value of their property worth 678 million Rwf. They however, requested for amicable ways of resolving the issue before proceeding with a court case. This correspondence indicated that their property valuation had been done by Dave Groups ltd and their lawyer was Maitre Laurent Nkongoli of "Cabinet d'avocays St. Yves".
- On the 10th November 2020, Nyenyeri village once again sent a letter to MoE and Ministry of Local govermment (MoL), thanking MoE and REMA for responding to their previous letter by visiting them to understand the actual issues first hand but unfortunately, they had not seen any progress on proposing solutions after that visit.

It is based on these complaints and correspondences that this Environmental audit was conducted.

Based on the complaints raised by the neighbouring village communities of Nyenyeri and Kabarore in these correspondences, the understanding of the inputs, outputs and emissions from literature reviewed on the cement production process, mass balance in the sub-chapters 3.2.1 and 3.2.2, and the boundaries of the scope of the Audit, the EA only analysed the following parameters for air, noise, vibration, stormwater and sediment quality from the factory's activities, in order to determine the level of compliance towards acceptable standards.

- Ambient dust measurements of Particulates matter ($PM_{2.5}$, PM_{10}) were taken.
- Sound levels were taken for noise monitoring.
- Vibration levels were monitored.
- For surface water of stormwater, the parameters that were measured and analysed were: pH, TDS, DO, COD, BOD, TSS, Nutrients (Cl^-, SO^{2-}_4, NO^-_3, PO^{3-}_4) and the following Heavy metals (Cd, Cu, Pb, Zn) were analysed for the water sample and sediment from the point of stormwater discharge.

5 AUDIT FINDINGS

5.1. Public consultation and field observation findings

Issues and opinions raised by stakeholders are presented in the Table 21 below. A photolog from the field visit of the factory's neighbouring communities in relation to the issues raised herein, is presented in Annex 1.

Table 21: Issues and opinions raised by stakeholders during public consultations.

Issues raised by Nyenyeri Village	Public consulted	Solutions proposed by those consulted
The Audit was informed by Nyenyeri village residents that the effects of CIMERWA activities on the community increased upon completion of the New factory. From the communities' point of view, while the old factory emitted dust, vibration and bad odour, it was not as a close as the New factory is to the residents. The New factory had been established on land partly owned by CIMERWA (previously the football pitch) and newly acquired land from private land owners in the neighbourhood of Nyenyeri village, which brought the factory in a distance of less than 10m for some residences of Nyenyeri village and hence directly affecting them. There was no health industrial buffer between the Industry and the residence. With more elaboration, the issues raised by Nyenyeri village residents were that: • Vibrations from factory machines have caused cracks in their homes. They claimed that the vibration effect from industry increased mostly after 9pm at night. • Loud Noise mostly from the crushers and ball mills. This not only was unbearable mostly at night but also was an opportunity taken by thieves to steal from their homes without hearing them. • Dust mostly from cement and coal blown by wind in their direction, cement dust from grounds of the packing area while coal is from the coal stock pile area. It got worse during the dry season. This was evident by the change of colour of their house roofs, leaves of trees for households close by. Residents claimed that they were no longer able to dry clothes or dry harvested maize grain or flour out and could not plant	Representatives from residents of Nyenyeri village, Shara cell, Muganza Sector	• Affected communities proposed the alternative of relocation, suggesting a location in Mashesho cell where CIMERWA already has land. • While for some cash compensation was proposed. • From key informant consultations among the community, the Audit was informed that Cimerwa had proactively carried out an informal valuation of houses likely to be expropriated should a buffer be an eventual resolution. About 60 homesteads had been proposed over an area 70m from the factory boundary wall on the side closer to the Cimerwa staff quarters and 40m from the end of the drainage channel at the other end of the boundary wall.

kitchen gardens in their homesteads due to dust contamination. They claimed that rain water harvested either had cement or was black water from coal dust. Some residents claimed they were facing respiratory distress and for some, their eyes were being affected by the dust from the Industry. • They claimed that storm water from CIMERWA had in the past destroyed some homes in Nyenyeri village, below the industry boundary. CIMERWA had compensated these losses by rebuilding affected houses and one was relocated to Gakenke village. 2 homes claimed to have been affected by storm water were relocated by the District. • Both Nyenyeri and Kabarore residents proposed a solution of relocation, however, expressed worry of relocation to areas far from basic needs and access to cultivatable areas, for example, one of the area disliked is known as "Kibangira" in Gombariro village in Ryankara cell, Bugarama sector close to the Rwanda-Burundi border.		
Issues raised by Kabarore Village	**Public consulted**	**Solutions proposed by those consulted**
Residents from Kabarore village shared same issues raised by Nyenyeri village except for the storm water that does not affect them. • They however have the Sandstone crusher closer, at the entrance and exit of the New factory, for which they emphasised dust emitted and noisy to the residents. • They are also closer to the Coal stock pile than the Nyenyeri village, which is a source of coal dust especially during the dry season. • They also claimed that the potable water tank above Kabarore village at times filled and spilled over, affecting the homes below it. • The number of homes in Kabarore village that have raised these concerns are about 62 homes. • They claimed that some residents upon signing the letters of complaints at CIMERWA, had lost their jobs as casual labourers.	Representatives from residents of Kabarore village, Shara cell, Muganza Sector	• Affected communities proposed the alternative of relocation, suggesting a location in Mashesho cell where CIMERWA already has land. • While for some cash compensation was proposed.

• Kabarore village residents have already commenced litigation with CIMERWA on impacts of; cracks on their houses from vibration, dust and noise.		
Issues acknowledged by the Sector office		
• Dust pollution was acknowledged as a negative impact to both villages. • While the Sector, concurred with Nyenyeri village of the effect of vibrations on their house walls cracking, it didn't think the cracking of houses for Kabarore village was entirely a result of vibrations from Cimerwa but for some instances was the construction material.. • The Sector informed the Audit that the New Cimerwa factory could be using more powerful machinery than the old factory and therefore a possible reason for increase in vibration levels. • Regarding the area masterplan, the Sector informed the Audit that the New Cimerwa factory is located under residential zoning of Nyenyeri.	Muganza Sector office	• The Sector proposed relocation of an area of Nyenyeri village to create an industrial bufferzone of 50-200m radius. • However, for Kabarore, it was not committal. • Some of the areas proposed for relocation are in Rubero village in Shara cell, where Cimerwa has land leased out to local cultivators and where the village is in close proximity to basic services such as; electricity, schools, roads. • In case of relocation, the option of exchange of land for land, house for house was proposed by the Sector as most sustainable rather than cash compensation for fear of affected households squandering cash compensated and becoming a social burden.
Consultation with Rusizi District		
• The District acknowledged complaints raised by the village communities of Nyenyeri and Kabarore were similar to the issues mentioned here above, with the proposition that:	Rusizi District	• Scientific data analysis from monitoring dust, vibration and noise levels could provide answers to the

○ The effect of vibration on some houses, which the District anticipated could be determined by scientific data from monitoring vibration levels. ○ The effect of flooding by storm water on Nyenyeri village occurs during rainy season, which might not solely be a problem caused by run-off from Cimerwa but a combination of Cimerwa run-off and run-off from the adjacent hills. • Regarding whether Cimerwa factory was located in the suitable District zoning, the Audit was informed by the Distict that there was no detail masterplan for this area and therefore Cimerwa is still located under residential zoning. The District also indicated that Cimerwa had existed in this location even before many of the residents and any existing land zoning or planned Area master plans. • Also, in regard to the area zoning, it was also observed that construction of the new Cimerwa factory was authorised by the District even though the area was still zoned residential and not Industrial.		issues caused by dust, vibration and noise levels.
Consultation with CIMERWA Plc		
• Regarding the issue raised of dust pollution at Cimerwa premise and along the road to the quarry, CIMERWA has been spraying water regularly on the road to the quarry and at the entrance/exit of the factory to reduce dust pollution. • It has also the current speed limit for CIMERWA haulage trucks at 40Km/hr to minimise dust pollution from speeding traffic along the quarry road. • Cimerwa, however, wishes to express its concern that the distance between the road and some community houses does not meet the road reserve requirements. Request is made for this to be looked at together with authorities responsible and appropriate action taken to reduce associated road safety risk to CIMERWA and the public. • In connection to issues raised of noise pollution, Cimerwa wished to inform that the factory was built by the Government and no buffer zone considered	Cimerwa Plc	• CIMERWA requests that a buffer zone preventing further development around CIMERWA factory is created. • Continuous Ambient Monitors have already been purchased and are to be installed around the factory zone to monitor the emission and noise levels to the community. • Discussion is proposed between CIMERWA, District authorities, authority in charge of Land use master plan, REMA, and other organs to align on (a) way forward regarding the issue

at that point. The community has continued to expand closer to the factory over the last 35 years. Most of the community houses were built after the factory had been constructed. • According to Cimerwa, in general, CIMERWA meets the requirements as per the industrial standard requirement. Nevertheless, Engineering solutions will continue to be implemented to reduce noise levels. The key challenge is the closeness of the Community to the Factory site where Zoning was not considered, and no control has been enforced over the years with respect to housing expansion towards the factory. • As for the complaints of vibrations causing cracks of houses, CIMERWA believes that area is located in a high seismic zone where always nature movement are happening that could be cause to cracks. Furthermore, some of the house cracks in the community are attributed to poor materials used to construct the house rather than vibration cause. • CIMERWA believes that it does its best to meet emission legal requirement standards. However, the current Masterplan of the areas that puts the factory in a residential area needs to be discussed with responsible authorities for a proper guidance.		of Masterplan of the area that puts the factory into a residential area and (b) how to solve the current settlement pattern at the factory, especially urgently preventing further building of houses close to the factory. Consideration should be given to the fact that the residential houses developed over the years after the factory was built.

Also, during public consultation, Cimerwa Plc wished to express what it has done for the community under its Corporate Social Responsibility (CSR) program, comprising:

- 19 families settled near Mashyuza Quarry were relocated and CIMERWA paid equivalent to 220 million Rwf for this activity**.**
- CIMERWA extracts, treats water from the nature stream and distributes to 7 community villages without any charge from them.
- CIMERWA constructed and supported school /educateur), on its land currently hosting about 700 children from the surrounding community.
- CIMERWA trained & equipped Local cooperative for sewing by providing 200 sewing machines. The current house used by the Local community sewing cooperative belongs to CIMERWA without any charge – a house supplied with water and electricity. Local sewing cooperative stitch CIMERWA staff's overalls and CIMERWA pays for Labour at a competitive cost.
- Constructed the market on CIMERWA land and handed it to local community, now currently in use.
- Huge pieces of land owned by CIMERWA is freely cultivated by surrounding community at no charge.
- CIMERWA maintain on a quarterly basis a public road through Mashyuza to Nyakabuye sector. other feeder roads have been maintained upon request of local authorities of Muganza and Gitambi sectors e.g roads in Nyenyeli, Rubeho.
- Provided support for extension of GS Mashesha school.
- Supplied 49 iron sheets to the families of Share cell to construct toilets and Kitchens.
- Built a modern House for a family of a Survivor of genocide against Tutsi.
- Rehabilitated 4 houses in Nyenyeri Village.
- CIMERWA clinic provide basic medical treatment to its staff, family members and surrounding community.
- CIMERWA ambulance is freely used to intervene to any community related medical emergency.
- CIMERWA provided Support to Espoir FC (district football team) &, Muganza FC, by providing 8Million Rwf.
- The current playground established and maintained by CIMERWA is used by the surrounding villages.
- Continue to fully support l'educateur nursery and primary school.
- During COVID-19 period, CIMERWA supported in the following areas:
  - Arrangements by CIMERWA enabled the Ministry of Health to conduct screening and testing of all CIMERWA staff and the surrounding communities.
  - A COVID-19 awareness and Road safety (Snakes and Hazards session was held with cement transporters.
  - CIMERWA pledged support for the construction of 11 automated hand wash stations to the District of Rusizi as per the District's request. These were completed and handed over. The total cost of the project was 16 million Rwf.
  - CIMERWA provided to community food items worth 6.4Million Rwf.
  - CIMERWA Provided clean tap water to Nyabishunju village.
  - Provided 5% net salary contribution to COVID 19 Fund (worth 21Million Rwf).
  - Approved 20Million Rwf to support construction of schools in line with Government Policy.
  - Provision of Face masks to the local community.
  - Awareness of Covid-19 control measures in different markets around CIMERWA plant, which is still ongoing.

5.2. Discussion of Emissions, ambient air quality, noise and vibration level results

5.2.1. Ambient levels of Dust

Ambient level of PM_{10} and $PM_{2.5}$ has been monitored at nine different locations around the factory. The sites are shown in the figure 14.

Figure 14: Location of sites (D1 --- D9) that were used for dust monitoring.

5.2.1.1. Levels of ambient dust pollution near cimerwa

To assess the compliance of the CIMERWA general area to the ambient air quality standard; four sites were continuously monitored for three to four days. This was necessary because 24 hours is the shortest period for which ambient air quality standards are defined.

Figure 15 below shows that $PM_{2.5}$ levels were below the maximum limit except for Sunday February 6th, where the site D6 was significantly higher than the standard limit. The site D6 is located 500 m away from CIMERWA on the road passing by the Shara primary school. The possible explanation for high $PM_{2.5}$ levels at D6 is that it is at a higher elevation uphill compared to the Cimerwa chimney heights and therefore the most susceptible site to $PM_{2.5}$ dust particles that are a lighter than PM_{10} and carried longer distances by wind.

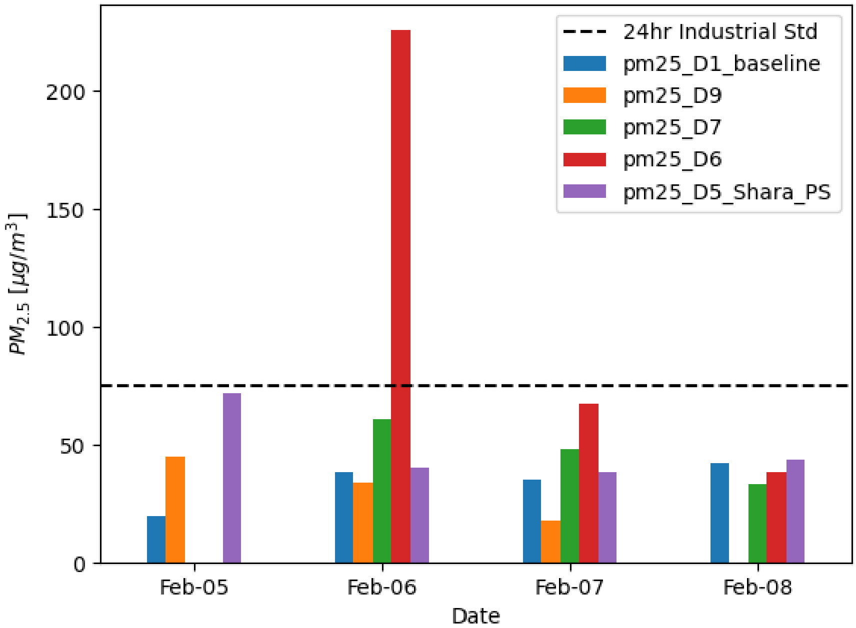


Figure 15: Ambient levels of $PM_{2.5}$ at four different locations compared to standards.

Figure 16 indicates that large particles (PM_{10}) violated the ambient standard limit on February 5th, and February 6th for D5 and D6 respectively. The two locations are close to each other, D5 being the Shara primary school which is located at 300 m from the factory.

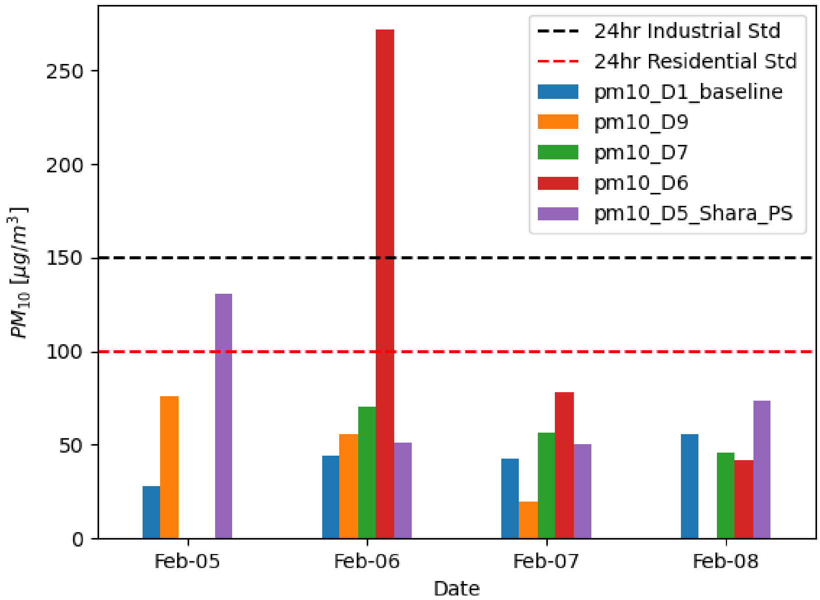


Figure 16: Ambient levels of PM_{10} compared to standards.

Five monitoring sites are shown in Figure 16 and Figure 16 because they are the ones that have been monitored for more than 24 hours and can, therefore, be compared to the standards. The remaining points were monitored for a few hours in order to quantify the impact of the factory at those sites.

5.2.1.2. Impacts of Cimerwa dust emissions to the neighbourhood.

To assess the impact of CIMERWA emissions to the neighbourhood; a baseline site that is not directly under emissions from CIMERWA was chosen to work as reference. The baseline site is D1 site in Figure 14. The working assumption is that all the sites would have levels and variability close to that of the baseline if there were no additional emissions from the factory. The baseline has been chosen in such a way that it is close enough to the factory to represent the study area but far enough and in a direction that does not usually get pollution from the factory. Under this assumption, the increase of pollution relative to monitoring sites is assumed to be coming from the factory. This approach permits to distinguish and filter out a general increase of pollution in area versus a localized increase that is caused by the factory emissions. For instance, figure 17,18 and 19 show that, generally, the main features of variability of PM_{10} and $PM_{2.5}$ at the baseline site (D1), at Shara primary school (D5) and at the upslope point (D6) were generally the same albeit with different levels of pollution.

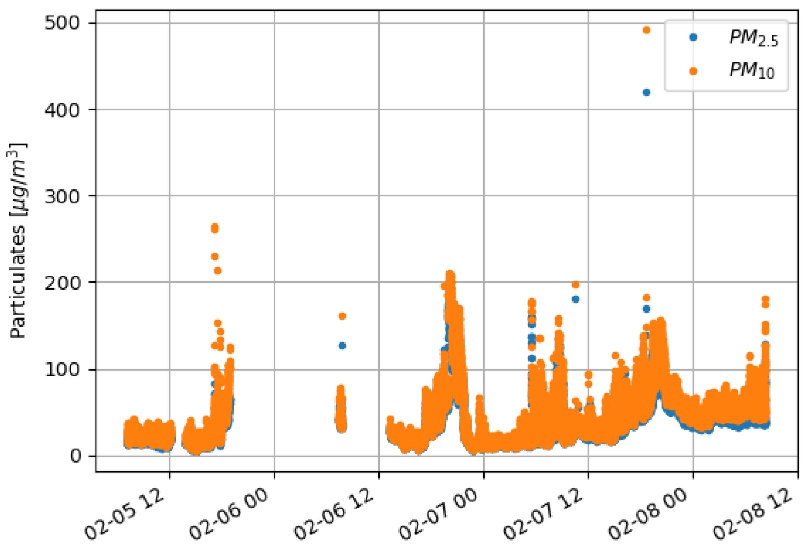


Figure 17: Dust level at the baseline site (D1) during the campaign

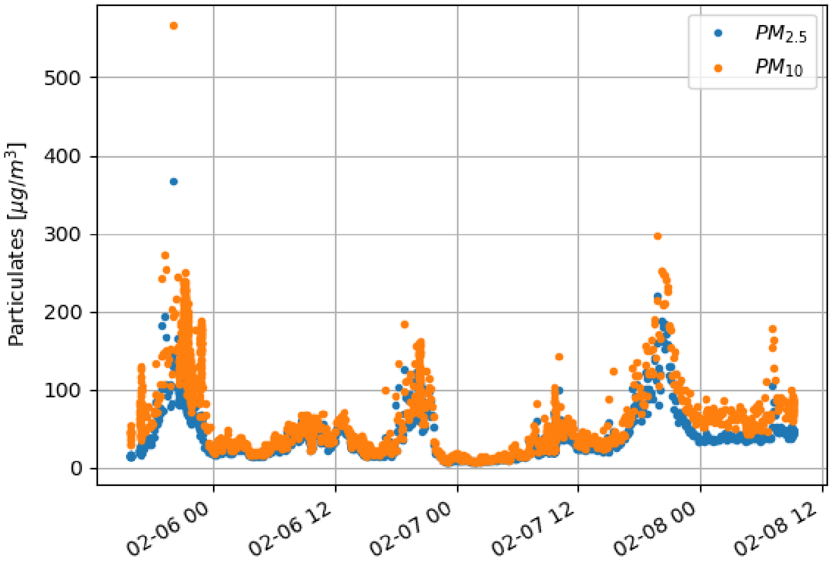


Figure 18: Dust levels at Shara primary school(D5)

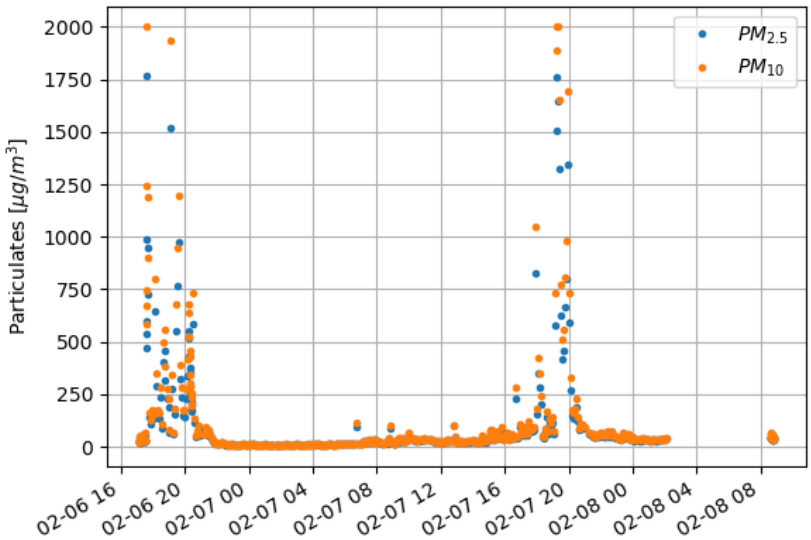


Figure 19: Measured dust level at site "D6"

Figure 20 to Figure 27 present impact of CIMERWA dust emissions to different monitored sites relative to the baseline. Horizontal lines representing the industrial standard for PM_{10} and residential standards for PM_{10} and $PM_{2.5}$ were also provided for reference. Most of sites were monitored for two to three hours and the 24-hour standards were used as the closest available. It shall be noted that baseline data values were different for each site comparative measurement since different baseline measurements had to be taken every time the monitoring equipment had to be shifted to measure a new site. The PM impact was based on comparison of the site measurements versus the baseline value at the same time of measurement.

Key findings in this comparison are that:

- It was observed that most sites immediately surrounding Cimerwa had $PM_{2.5}$ and PM_{10} levels below the 24hour industrial and residential standard.
- Sites located in the South West direction of the factory are the least affected by dust pollution. A good example of such a site is the Educateur school (D2) (Figure 22). It was observed that the prevailing wind direction (blowing easterly from Nyenyeri D4,8,9 to D7,3,5,6) and its (D2) relatively lower altitude compared to the factory resulted in this finding.
- The site most affected is D6 which is located towards the East (downwind) of the factory and at a higher elevation (above factory chimneys) than the factory, therefore making it receive higher pollution of $PM_{2.5}$ and PM_{10}.

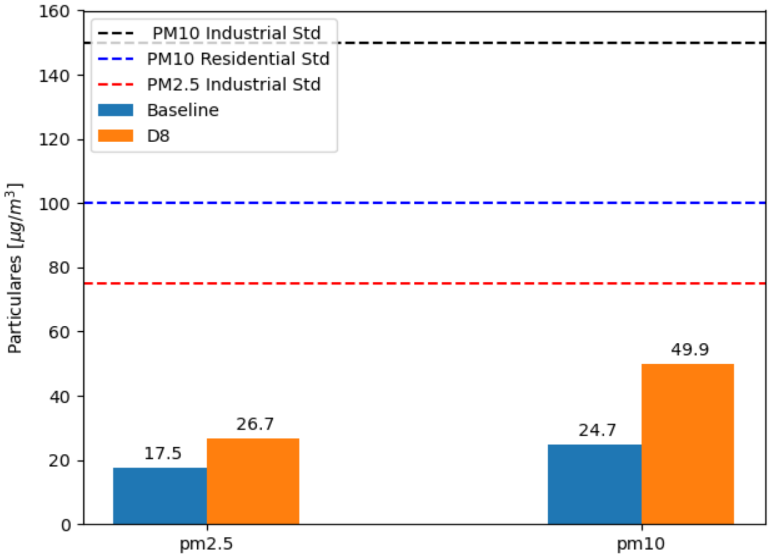


Figure 20: Comparison of dust level at site "D8-Nyenyeri village" relative to the baseline.

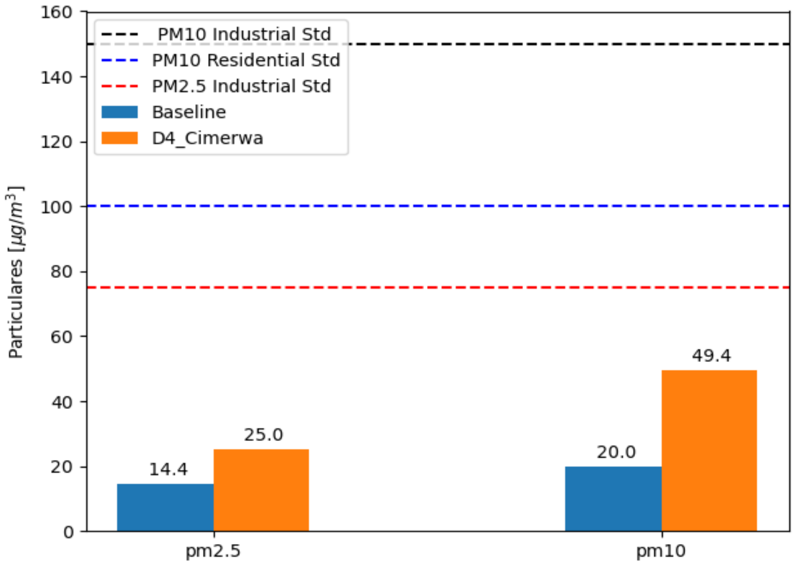


Figure 21: Dust level inside CIMERWA "D4" compared to the baseline.

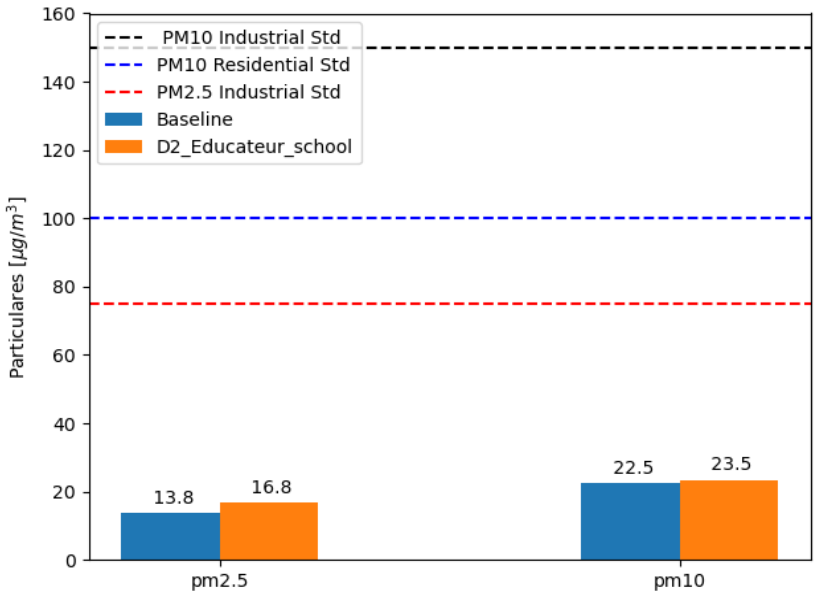


Figure 22: Dust level at "D2" l'Educateur primary school compared to the baseline.

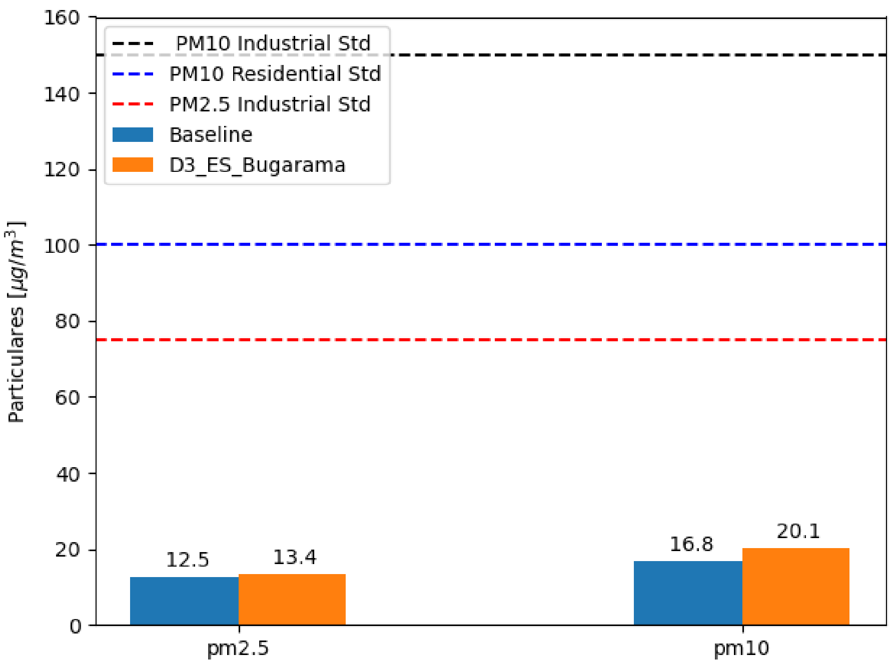


Figure 23: Dust level at "D3" E.S. Bugarama compared to the baseline level.

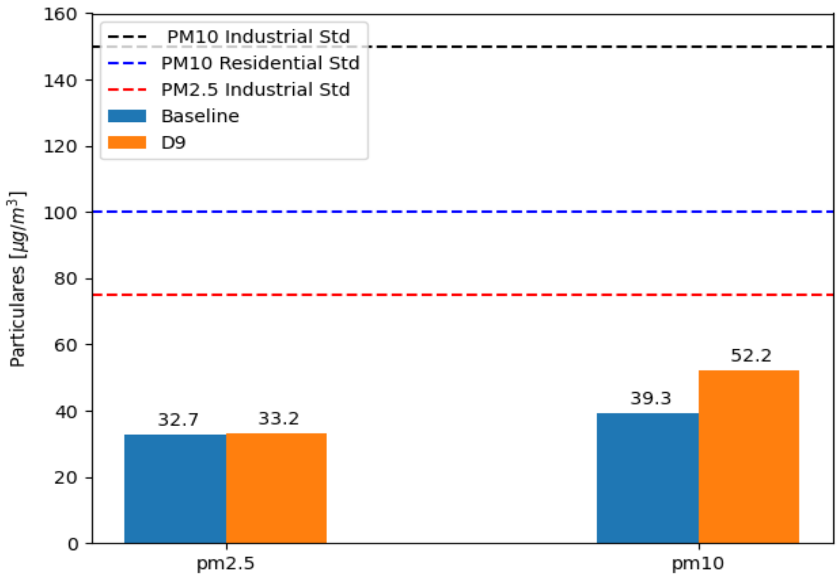


Figure 24: Dust level at the site "D9" compared to the baseline.

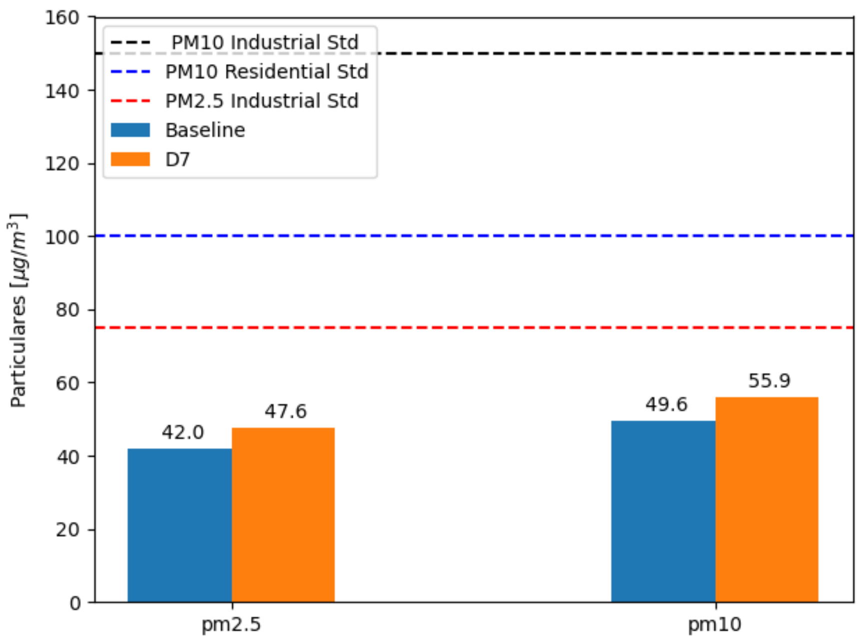


Figure 25: Dust level at the site "D7" compared to the baseline.

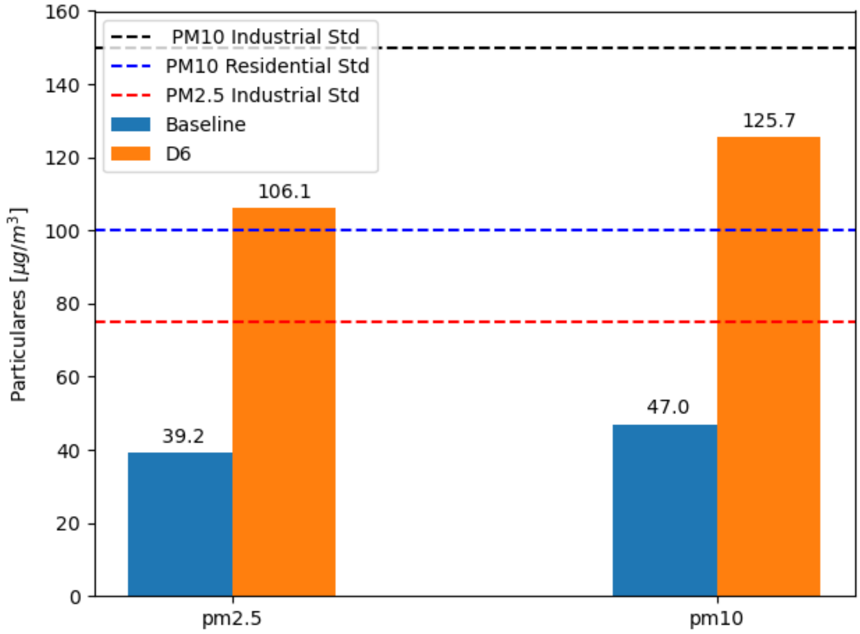


Figure 26: Dust level at site "D6" compared to the baseline.

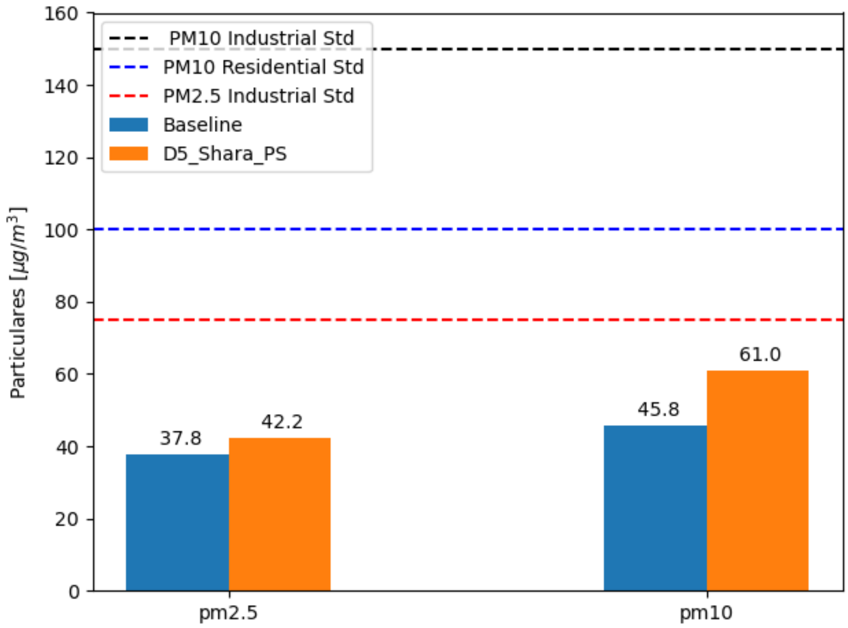


Figure 27: Dust level at "D5" Shara Primary School compared to the baseline.

A summary of percentage contribution of CIMERWA emissions to its neighbourhood is presented in Figure 28, which highlighted that for both PM_{10} and $PM_{2.5,}$ an increase of 102.1% and 52.4% respectively was observed at D8, 147.1% and 74.2% respectively was observed at D4 within Cimerwa premises, 32.9% and 1.4% respectively was observed at D9, 167.3% and 170.4% respectively was observed at D6.

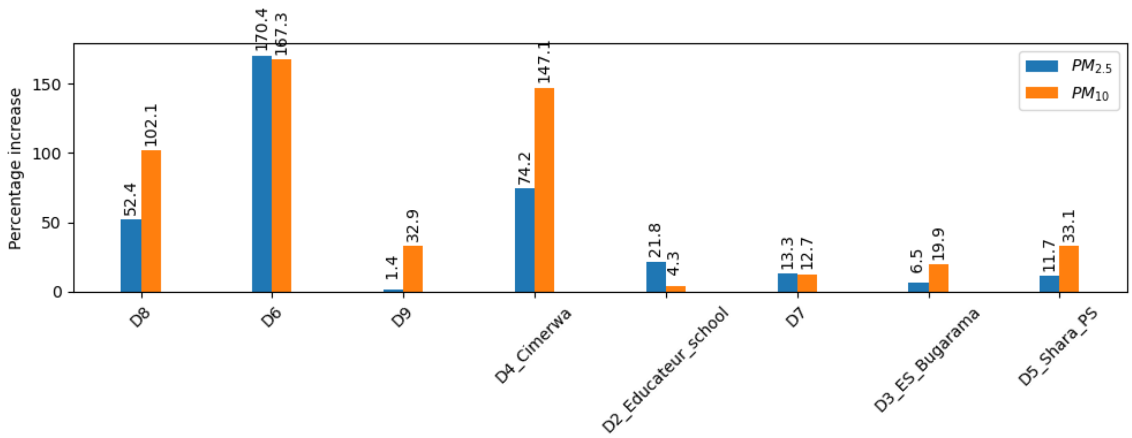


Figure 28: Percentage of increase in ambient dust at different sites that are attributed to CIMERWA factory emissions.

In addition, the Audit assessed the extent to which the dust from the factory affects the neighbourhood. The exact coordinates of sites used are presented in table 5. Point1 to Point5 are approximately at 50m, 200m, 350m, 600m and 850m respectively.
Figure 30 below shows that levels of dust compared to the baseline levels. At Point 5 which is at 850m away from the factory, results indicate that below that distance, residents are exposed to relatively higher levels of dust compared to baseline dust levels attributable to dust emissions from the factory.

Figure 29: Location of sites used to assess the impacts of dust emissions at various distances.

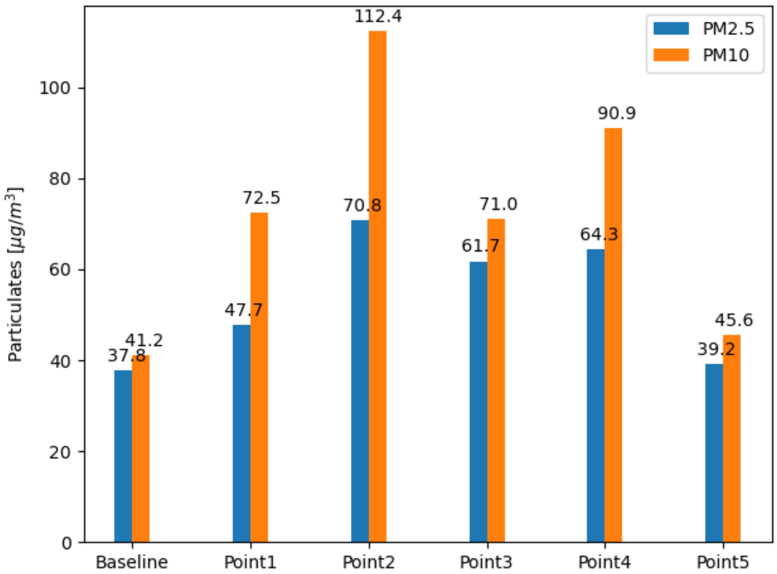


Figure 30: Levels of dust at various locations from the factory compared to the baseline.

Conclusive remarks on Cimerwa ambient dust emission impact on the neighbourhood:

- The percentage increase of ambient dust at different sites and ambient dust levels discussed above as a contribution of emissions from Cimerwa might not be a conclusive reference for compliance and pollution in comparison to the national standards due to the fact that measurements taken during this audit were only for afew days(i.e. a short period) and yet comparison of measurements with standards require analysis of continuous monitored measurements for a year(i.e. a longer period that will capture emission impacts based on seasonal changes, weather patterns, regional effects, unusual incidents of high emissions based on factory activities) for comparison of compliance against the national standards.
- However, the higher PM_{10} and $PM_{2.5}$ levels of other sites compared to the baseline site in this audit's analysis show that other sites are exposed to relatively higher levels of dust than the baseline by virtue of proximity to Cimerwa.
- Levels of dust pollution comparable to the baseline levels are obtained at about 850m from the factory in the uphill direction.
- Dust deposits observed on trees and roofs of houses in the neighbouring communities as mentioned in the public consultation in section 5.1, could be a result of dust deposits arising from diffuse dust emissions by Cimerwa from unusual incidents of exceptional emissions due to equipment malfunction, bag house filter failure, maintenance works, and changes of weather patterns for example winds during dry season blowing cement dust from Cimerwa grounds towards communities. Monitoring of dust emissions under such irregular circumstances could not be monitored during the short period of the audit.

5.2.1.3. Impacts of the quarry road to the adjacent resident.

The Audit also assessed the impact of the road to the quarry to nearby residents. A baseline site was selected, and five monitoring sites were selected 50 meters apart in the direction perpendicular to the road as shown in figure 5 and 6. As highlighted in figure 31, most of pollution from the raw material transport is larger dust particles (PM_{10}) likely caused by dust resuspension due to an unpaved road. The dust deposits quickly and at 150 m from the road the dust level is comparable to the baseline level.

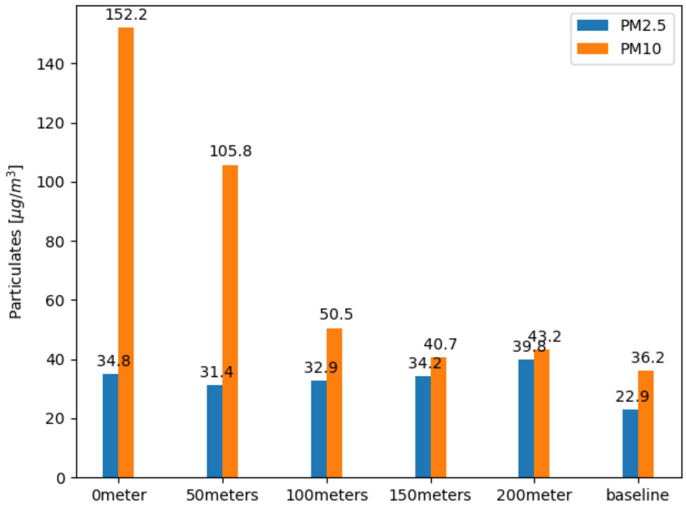


Figure 31: Dust levels at various distance from the road to the quarry compared to the baseline value.

5.2.2. CIMERWA availed data on Stack emissions compared to standards.

For completeness of this report, CIMERWA has provided the dust emissions data for the whole year of 2020 as measured at its main kiln stack. Monthly mean data were plotted against the 50 mg/Nm^3 set out by the standard RS EAS 752:2010, Air quality — Tolerance limits of emission discharged to the air by factories.

Measured data have been converted to reference conditions (normal conditions) of pressure (101.3kPa), temperature (273 K) and oxygen (10%) as provided by the standards. To convert the concentration as measured at a temperature of T [Kelvin] to the concentration at 273.15 K, multiply by F_t where[7]:

$$F_t = \frac{T[K]}{273.15}$$

To convert the concentration as measured at a pressure of P [kPa] to the concentration at 101.3 kPa, multiply by F_p where:

$$F_p = \frac{101.3}{P}$$

To convert a concentration "as measured" to a concentration at reference oxygen level, multiply the concentration by F_o, the correction factor for oxygen, given by:

$$F_o = \frac{20.9 - O_2\%\,reference}{20.9 - O_2\%\,measured}$$

The flue gas temperature, pressure and oxygen levels were provided. However, the pressure provided was negative and unreasonably low (3 to 4 thousand Pascal). For pressure correction, we used an estimate value of 89.8 kPa which represents the pressure of the standard

[7] https://www.epa.ie/pubs/advice/air/emissions/Air%20Mon%20Guid%20Note%20_AG2_%20-%20final%20version2.pdf

atmosphere (average conditions) at 1 km of altitude above sea level which is closest to the altitude of CIMERWA of 1,120 m above sea level.

As shown in Figure 32**Error! Reference source not found.**, CIMERWA data shows that the Kiln dust emissions did comply with the tolerance limit set out by the standard.

CIMERWA kiln emissions data imply that the main source of dust pollution is fugitive emissions, which are those emissions that are not channeled through the stacks. The standard RS EAS 750:2010 Air quality — Emissions to the air by cement factories — Guidelines, recognizes that monitoring fugitive emissions directly is impractical and recommends a visual control only. For the case of CIMERWA, cement dust deposited on the roofs of nearby residential buildings, tree leaves and the ground can constitute such a visual control and document, indeed, the presence of significant fugitive emissions.

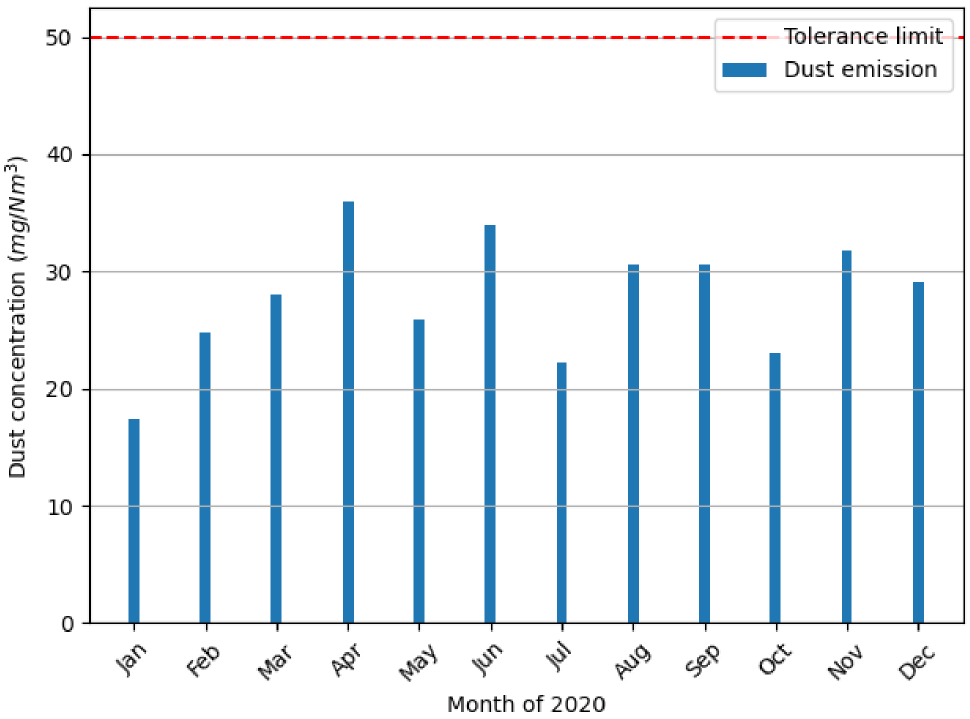


Figure 32: Monthly mean Kiln dust emission data from Cimerwa compared to standard's limit.

5.2.3. Ambient Noise Level

Noise levels have been monitored at eight different sites during days and nights. The sites that were used for noise monitoring are presented in figure 33 below.

Figure 33: Sites that were used for ambient noise monitoring.

5.2.3.1. Ambient noise levels compared to standards.

Measured noise levels have been compared to standards as presented in Table 3. Residential standards were used in the areas that are not silence zones (i.e., schools) or inside the factory where only industrial standard apply.

In general, noise levels are above the permissible standards for most sites except at the site N1 which is lower in elevation than the factory and sites (N4 and N5), which are inside the factory as a more permissive industrial standard is applied for them.

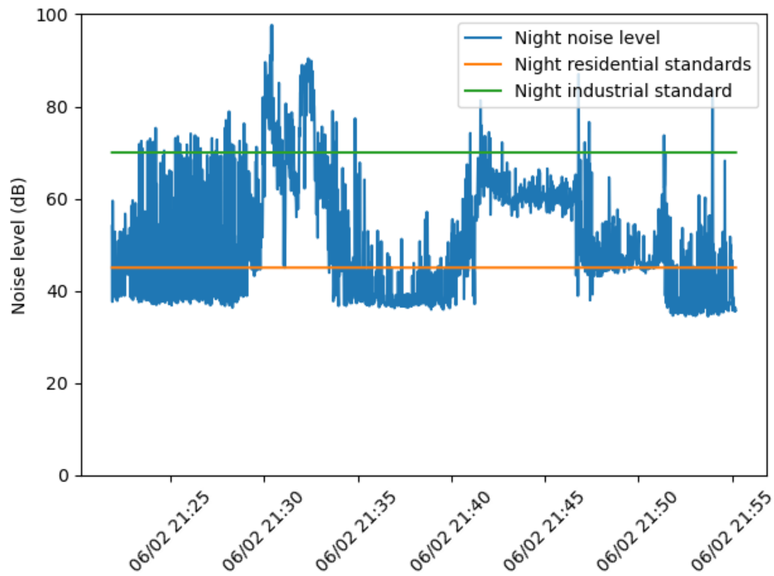


Figure 34: Noise level at site "N7" in Nyenyeri village

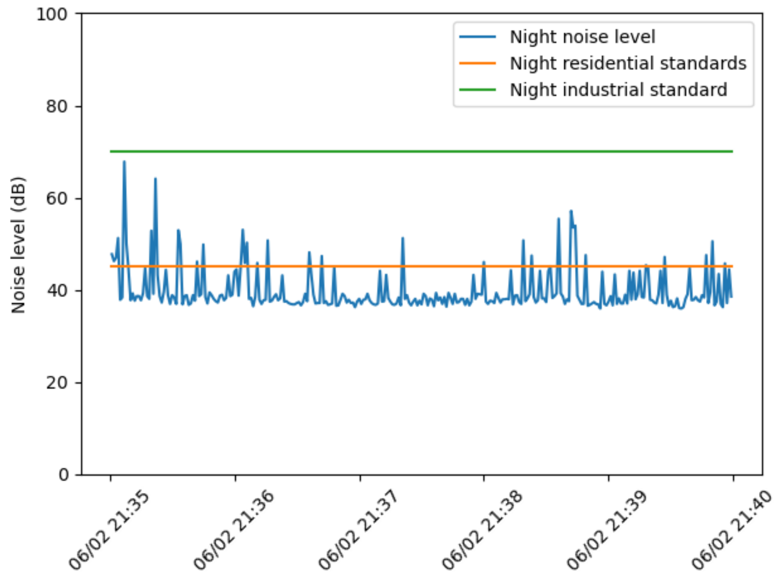


Figure 35: Noise level at site "N9" in Nyenyeri village

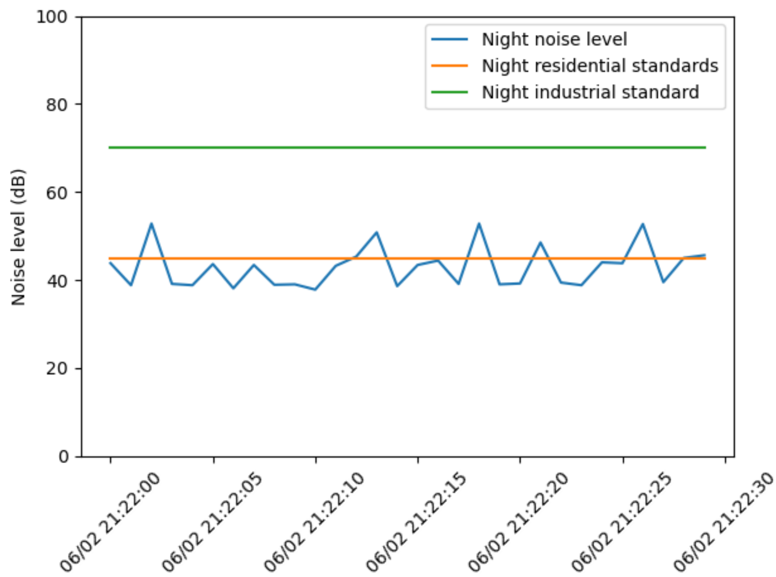


Figure 36: Noise level at "N10" in Nyenyeri village

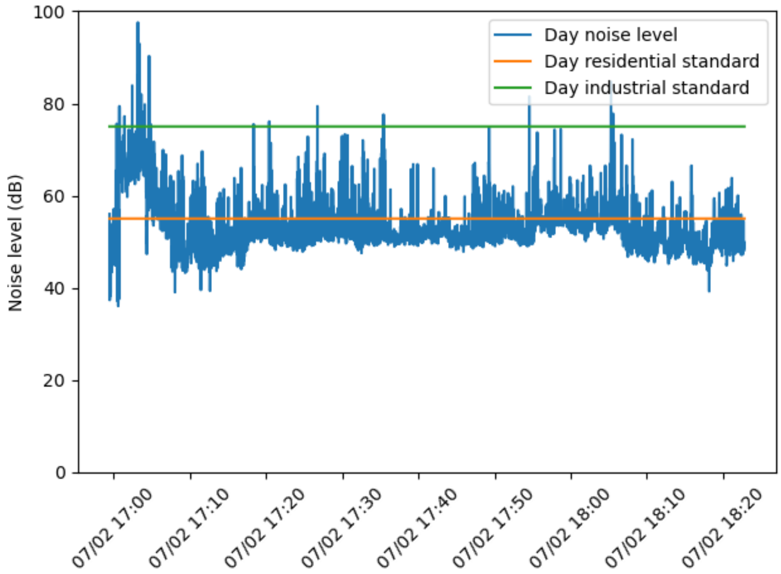


Figure 37: Noise level at site "N8" on hills above Kabarore village.

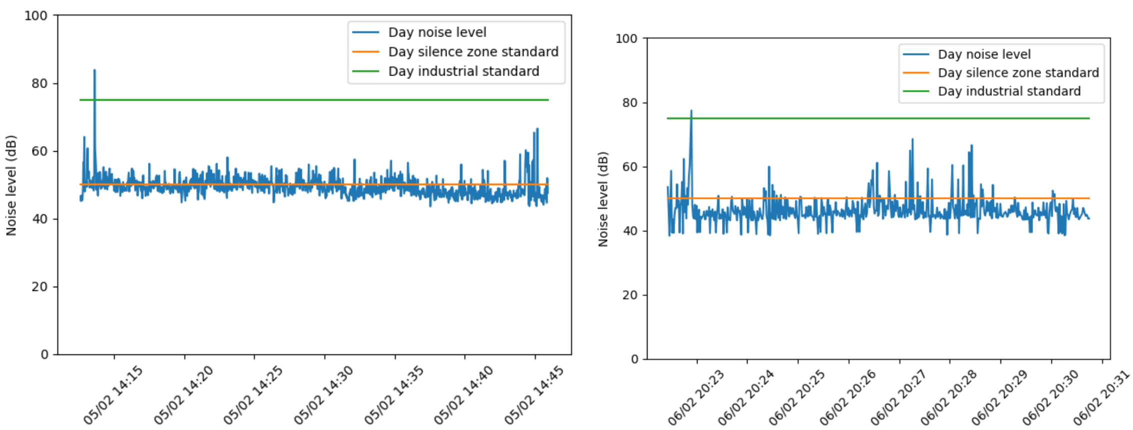


Figure 38: Noise level at the baseline site "N1" at two different times of the day (morning and evening) are within the applicable industrial standard but non-compliant for night noise level residential standards.

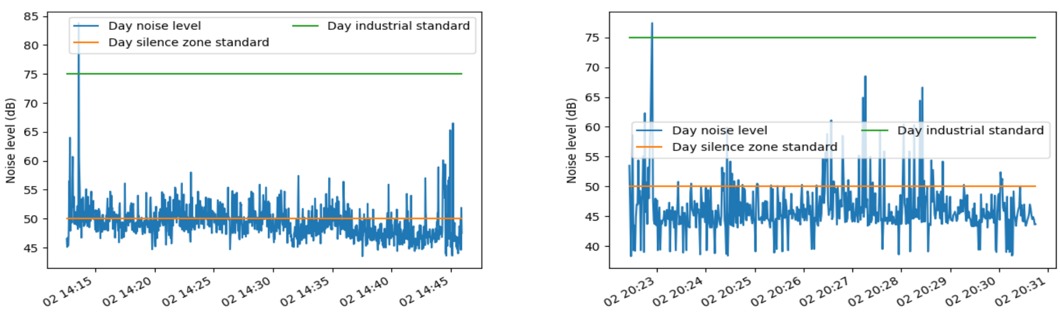


Figure 39: Noise level at the Educateur (N2) school at two different times of the day with applicable standards (Silence zone) shown and the industrial standard presented for reference.

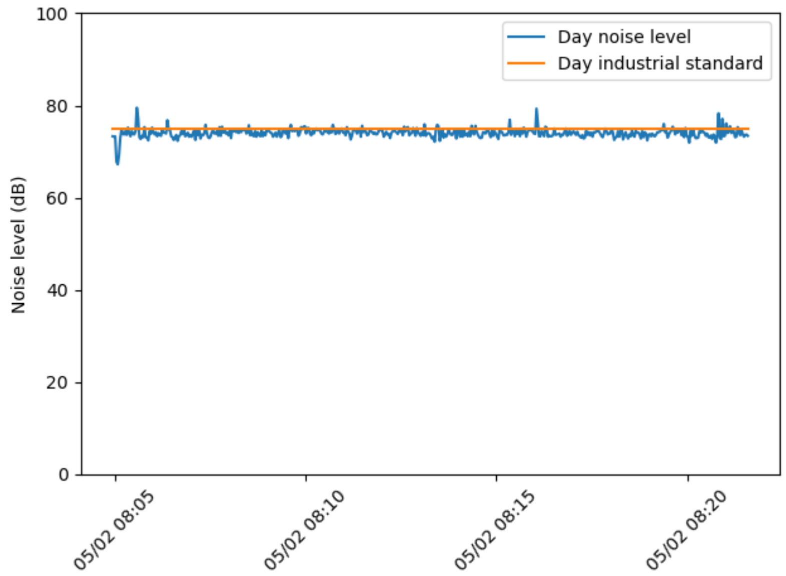


Figure 40: Day Noise level at CIMERWA parking (N4) mostly with in the industrial standard but closer to exceeding the standard.

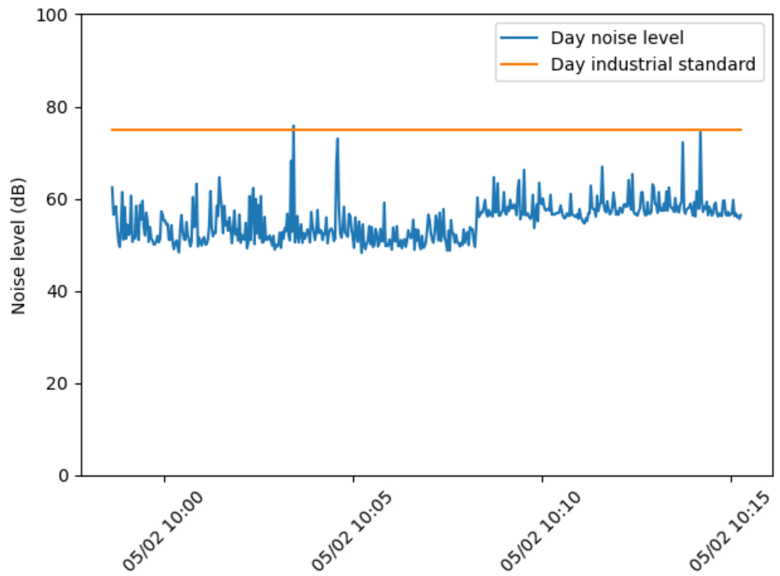


Figure 41: Day Noise level inside CIMERWA (N5) within the industrial standard shown by a horizontal line.

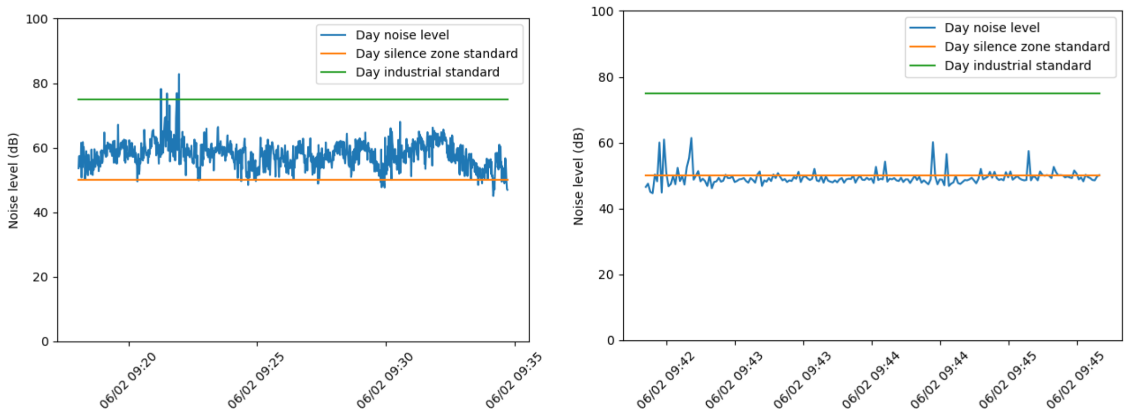


Figure 42: Noise level at two sites within Shara Primary school (N6)

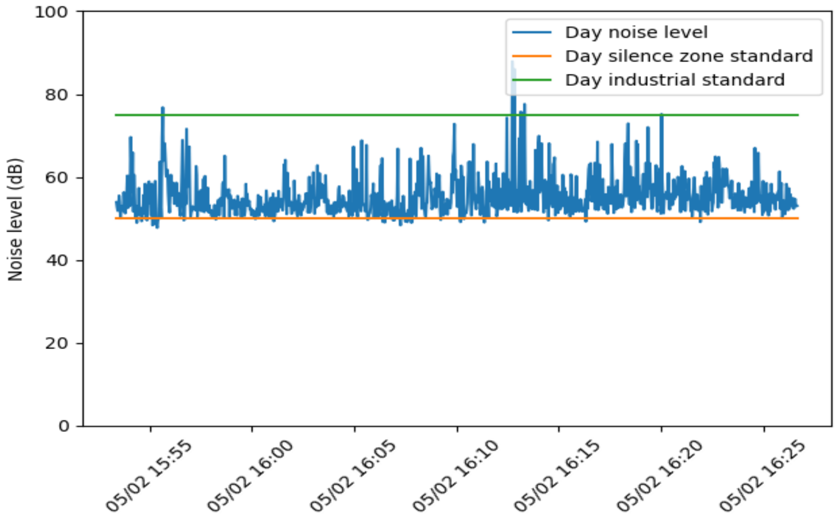


Figure 43: Noise level at E.S Bugarama (N3)

5.2.3.2. Ambient noise variation with distance from the factory

The Audit assessed the variation of ambient noise with respect to the distance from the factory by selecting six different sites 100 m apart located at a radial distance centred at the factory as shown in figure 44.

The resulting findings are captured in figure 45, which represents the maximum, minimum and mean value of noise levels measured at those distances. The Audit observed that acceptable noise levels were obtained at 500 m from the factory.

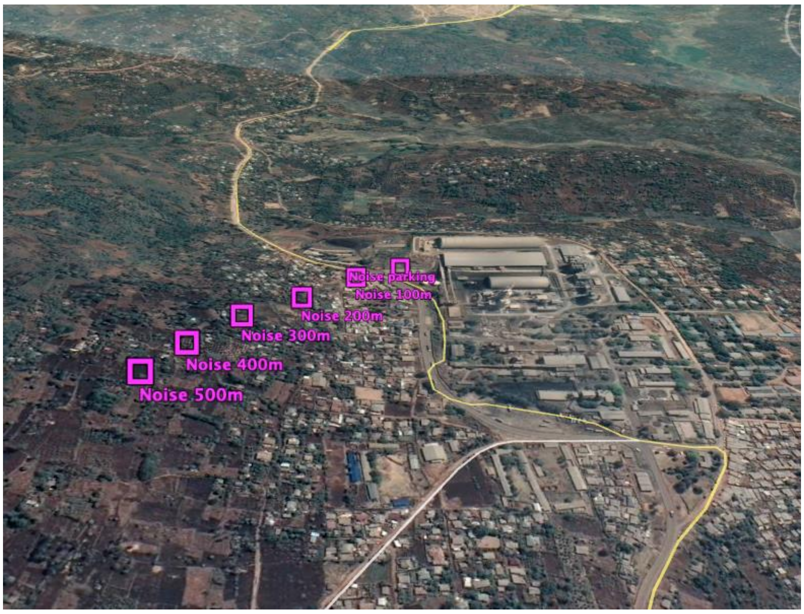


Figure 44: Sites used to measure the variation of noise with distance.

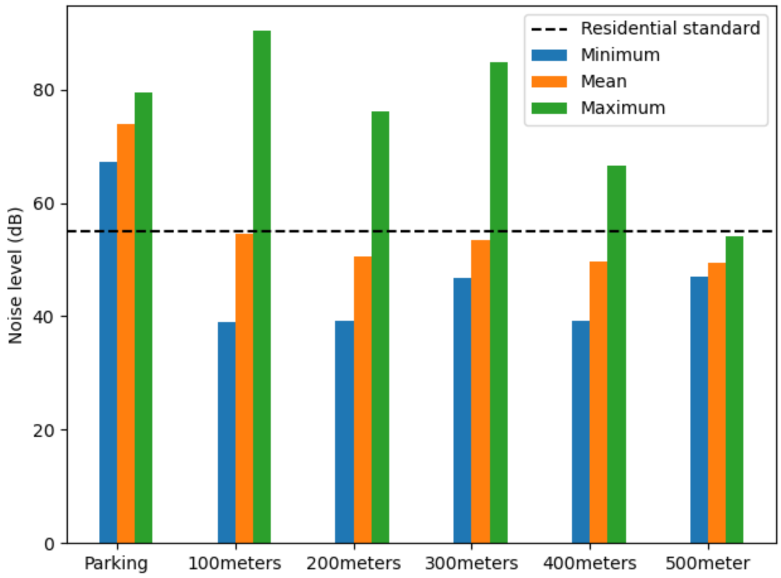


Figure 45: Ambient noise variation with distance from the factory

5.2.3.3. Baseline ambient noise levels

For completeness the audit assessed the baseline noise levels for the general area; the objective of this exercise was to provide an indicative (and approximate) measure of how the ambient noise would be like without a factory and related activities.

The Audit chose a site located 2 km away from the factory in the South direction that is similar to CIMERWA area in many aspects including topography, population density and proximity to the main road Bugarama-CIMERWA as shown in Figure 46.

Figure 46: Location of sites used for baseline ambient noise.

As shown in Figure 47 through to figure 50, baseline levels were in the range between 35 dB to 45 dB with brief increase reflecting human activities near the sensor including children playing. Occasion violation of ambient noise standard level were observed when vehicle and motorcycles passed near the sensor located at the sides of the road.

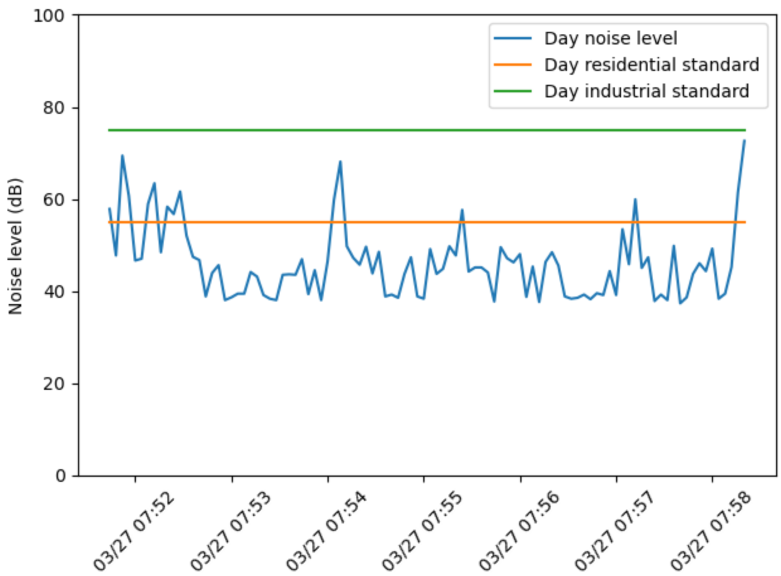


Figure 47: Baseline noise level measured at the side of the road (Point 1)

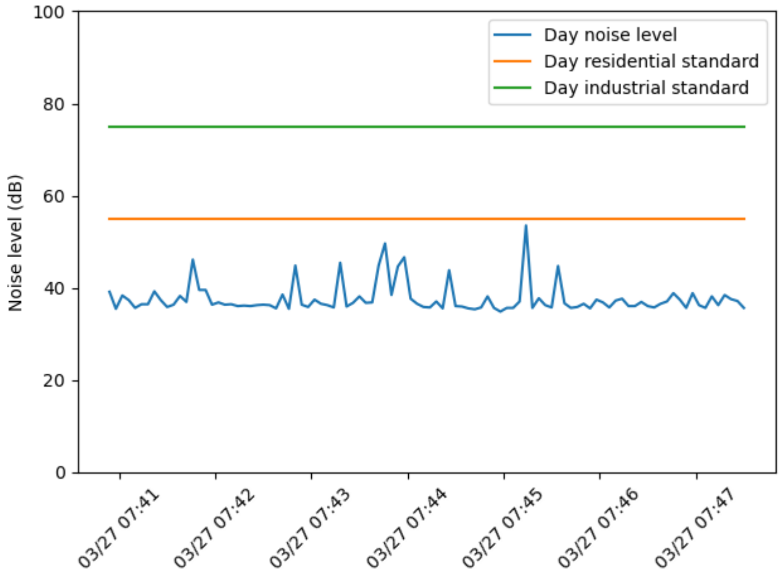


Figure 48: Baseline noise level measured at 30m from the road (Point 2)

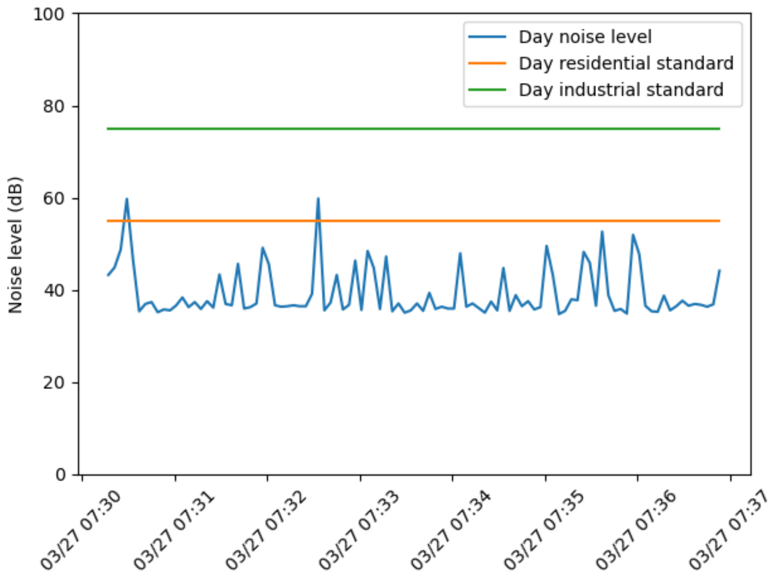


Figure 49: Baseline noise level measured at 60m from the road (Point 3)

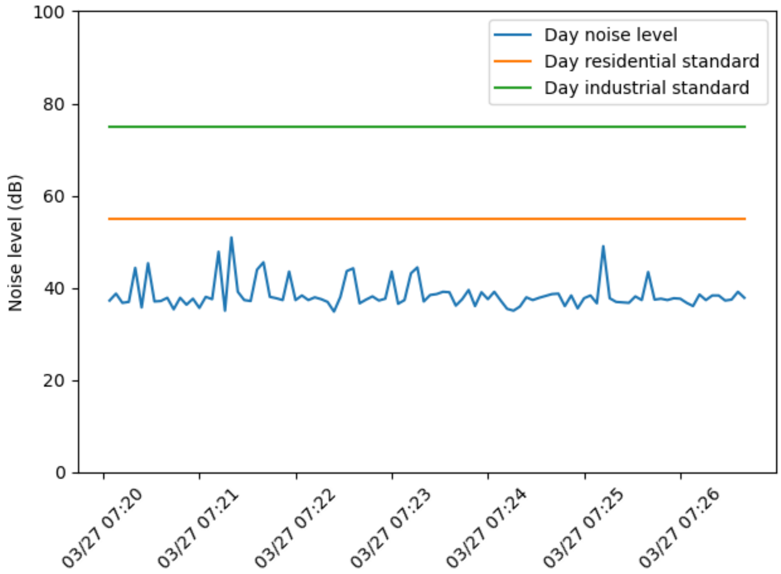


Figure 50: Baseline noise level measured at 100m from the road (Point4)

5.2.4. Vibration Levels near Cimerwa compared to standards.

Ground vibration were monitored at five locations as highlighted in figure 51. The measure peak particle velocities (PPV) are presented in figure 52 below. The highest PPV were obtained inside the factory near the main crusher site which was still below the set standard of 5mm/s. However, these vibration measurements were taken when the mobile crusher was not operating which is expected to be the one responsible for most ground vibrations. As discussed in section 3.3.3, vibration is dampened quickly near the source. Consequently, the lack of vibration data resulting from operation of the mobile crusher may affect the findings on residents directly adjacent to the factory but would not inform recommendations of the buffer distance to mitigate its impact.

Figure 51: Vibration monitoring sites "V1 to V5".

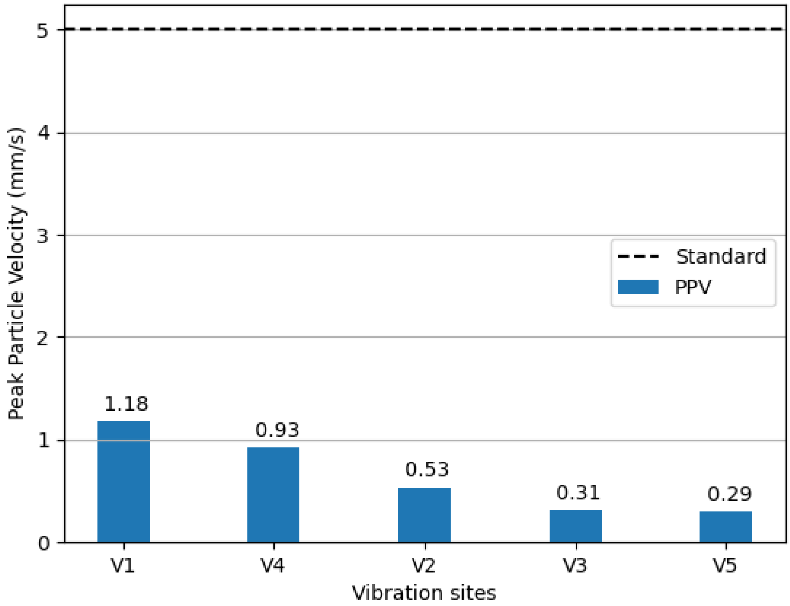


Figure 52: Peak Particle velocity (PPV) measured near and inside the factory.

5.3. Discussion on water and sediment quality results

5.3.1. Summary of results of Storm water laboratory analysis

A summary of results for in-situ and laboratory analysis of stormwater samples taken at the industry is presented in the table below for immediate reference. Detailed analytical discussions follow in proceeding sub-chapters, with explanations of probable reasons of levels for each parameter and compliance levels of effluent to surface water.

Table 22: Summary of results of stormwater laboratory analysis

pH	Conductiv (µS/cm)	TDS (mg/l)	TURB (NTU)	COD (mg/l)	BOD)mg/l)	TSS (mg/l)	CHLORIDE (mg/l)	SULFATE (mg/l)	Nitrate Nitrogen (mg/l)	PHOSPH (mg/l)	Oil&GREAS E (mg/l)
11.76	2710	1482	575	304	2.45	200	65.04	52	2.6	3.4	Not detected
Copper (mg/l)	Cadmium (mg/l)	Lead (mg/l)	Zinc (mg/l)								
0.133	0.394	0.106	0.243								

5.3.2. Discussion of water quality results

5.2.1.4. pH

The result of pH measured from storm water shows a pH alkaline of pH 11.76 as shown in the figure 53, which is above the high permissible limits of pH 8.5 of standards for surface water.

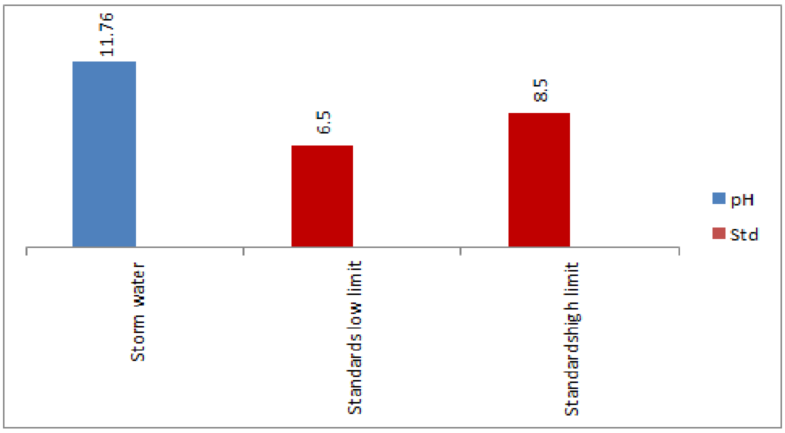


Figure 53: pH level of storm water

In order to predict the possible cause of a high alkaline pH for Cimerwa stormwater effluent, the Audit reviewed literature from different relevant studies. According to a study done by (Ipeaiyeda & Obaje, 2017) on the impact of cement effluent on water quality of rivers, it was similarly found that run-off water effluent from the Obajana cement plant in Nigeria had the pH range of 9.1 ± 0.9 suggesting that the effluent was alkaline in nature. The explanation given for the alkaline pH in that study that could also apply to the cause of an alkaline pH 11.76 of Cimerwa effluent in this Environmental Audit was that the reaction process of calcium carbonate ($CaCO_3$), aluminium oxide (Al_2O_3), silica oxide (SiO_2) and iron oxide (Fe_2O_3) as raw materials for cement production, could result in cement effluent that is alkaline, with a potential of imparting high alkalinity to the effluent receiving soils and groundwater. This argument is backed by another study by (H.M. Paula & M.S.O Ilhla, 2014), which observed that cement is rich in carbonates and bicarbonates, which was the primary cause of the elevated alkalinity pH values.

High alkalinity in soils impairs plant growth by restricting water supply to the roots, thus obstructing root development and stunting them. It results in phosphorus and zinc deficiencies, and possibly iron deficiency and boron toxicity. Plants have less ability to extract essential nutrients from the soil when damaged by alkalinity.

5.2.1.5. Conductivity

Conductivity is a measure of the water's ability to conduct electricity, which also provides a measure of solids dissolved in water. A higher conductivity value indicates that there are more chemicals dissolved in the water.

The result of Conductivity measured from storm water in this Audit shows a high level of conductivity 2,710 µS/cm beyond the permissible limit by National standard of 1,000 µS/cm, as shown in the figure 54 below. This high conductivity is simply an indication of high ions concentration, high dissolved solids (TDS) of chemicals and minerals present in the water, a possible indication of high impurities in the water and confirmation of the high levels of TDS in the proceeding sub-chapter.

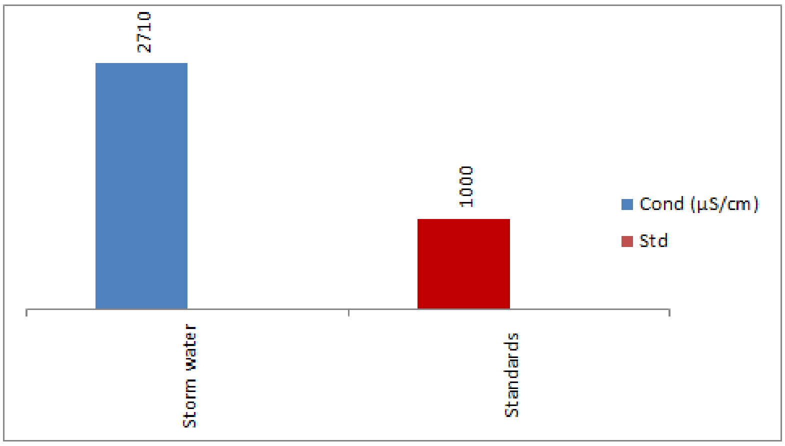


Figure 54: Conductivity measured of Stormwater.

5.2.1.6. Total Dissolved Solids (TDS)

The result of TDS measured from storm water shows a higher level of TDS of 1,482 mg/l beyond the permissible limit by National standard of 500mg/l as shown in figure 55 below.

Just like conductivity, the high TDS above permissible limits is a possible indication of high impurities in the water from dust of cement, coal, limestone, sandstone and pozzolana raw material.

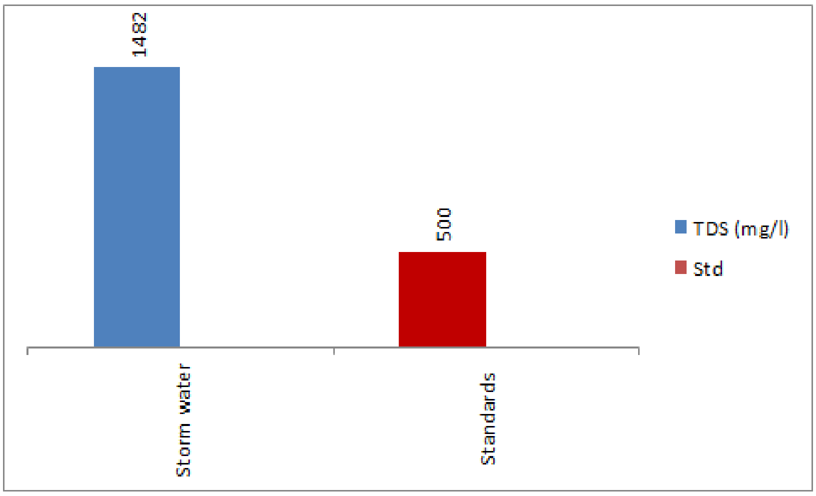


Figure 55: TDS measured of Storm water.

5.2.1.7. Turbidity

The result of Turbidity measured from storm water shows a higher level of Turbidity of 575 NTU above the permissible limit of 5NTU as shown in the figure 56 below.

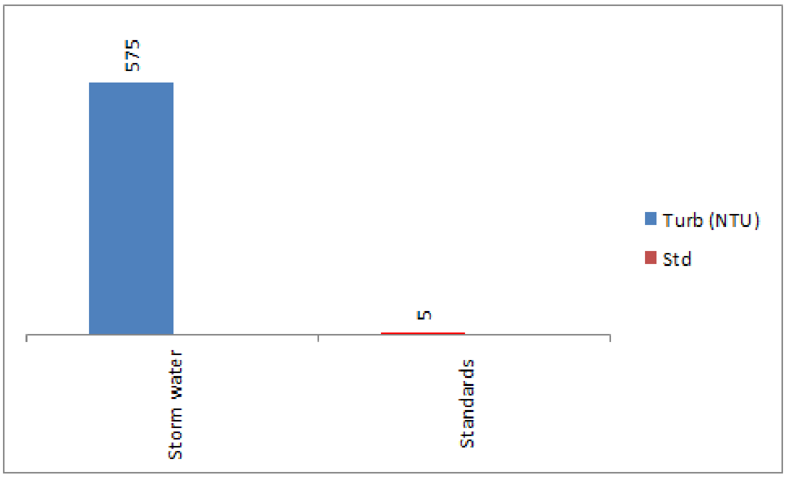


Figure 56: Turbidity measured of storm water.

According to (Ipeaiyeda & Obaje, 2017), such high turbidity levels as in the Cimerwa effluent, were observed to have originated from dissolved dust and solids from the crushing of raw material, kiln and the packing area. High turbidity in effluent and high total suspended solids as presented in the proceeding sub-chapter, were the probable reason for the quick filling up of pits excavated as a measure to collect and hold discharged cement effluent at the Nyenyeri village boundary wall and possibly contributing to flooding of some homes as reported in the public consultation. Turbid effluent could also interfere with receiving water streams downhill by reducing sunlight penetration which may affect food supplies and growth of aquatic organism. For example, streams that feed into Rubyiro river and in Bugarama rice wetland.

5.2.1.8. Total Suspended Solids (TSS)

As presented in the figure 57 below, the result of TSS measured from storm water shows a high level of TSS 200 mg/l compared to the permissible limits of 30mg/l. This too can be explained by the dust and solids washed by run-off from raw material sheds, crushers of limestone, sandstone, pozzolana, coal, cement dust from concrete floors.

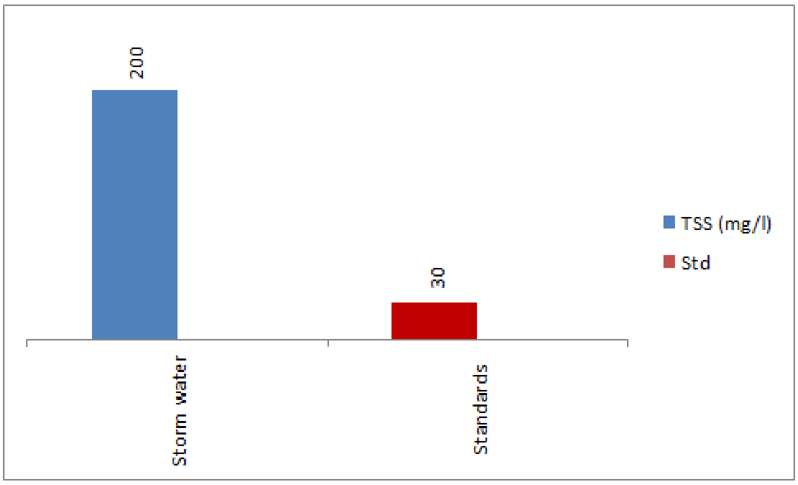


Figure 57: TSS measured of storm water.

Like turbidity, high TSS in effluent could have been the reason for the quick filling up of pits excavated to collect and hold discharged cement effluent at the Nyenyeri village boundary wall and possibly contributing to flooding of some homes as reported during public consultation. High TSS in effluent could also interfere with receiving water streams downhill by reducing sunlight penetration which may affect food supplies and growth of aquatic organism. For example, streams that feed into Rubyiro river and in Bugarama rice wetland.

5.2.1.9. Chemical Oxygen Demand (COD)

The result of COD measured from storm water shows a high level of COD of 304 mg/l above the permissible limit of 50mg/l as shown in the figure 58 below. This is an indication of gross chemical load of the effluent as observed in (Ipeaiyeda & Obaje, 2017), again resulting from reaction processes of calcium carbonate ($CaCO_3$), aluminium oxide (Al_2O_3), silica oxide (SiO_2) and iron oxide (Fe_2O_3) as raw materials for cement production.

High COD level implies a high amount of chemically oxidizable organic material in the sample, which will reduce dissolved oxygen (DO) levels. A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life forms for any receiving water body, likes of streams in the neighbourhood that feed into Rubyiro river about 1 km.

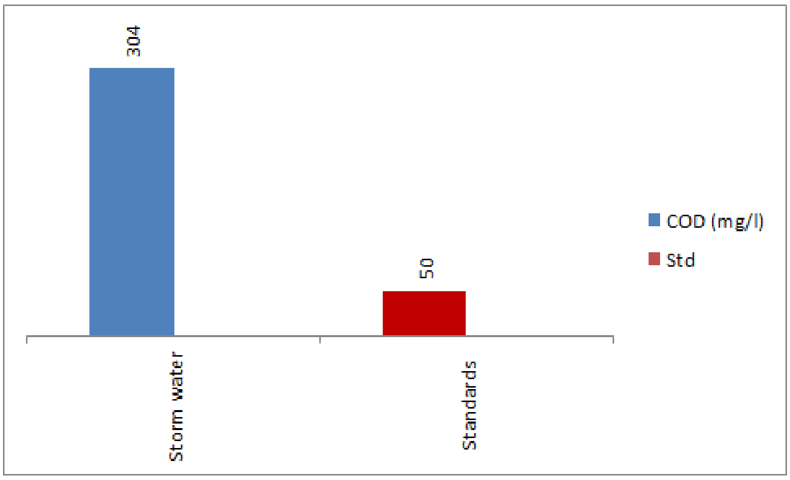


Figure 58: COD measured of storm water.

5.2.1.10. Biochemical Oxygen Demand (BOD)

The result of BOD measured from storm water shows BOD level of 2.45 mg/l within permissible limit of 30mg/l as shown in the figure 59 below, implying that there are low levels of biodegradable organic matter in the effluent and the chemical composition of cement in the effluent does not affect the BOD of storm water. On another note, low BOD levels could be an indication that all source of organic matter such as sewage and solid waste are well contained in the septic treatment tank and well managed on the premises respectively, consequently not mixing with rainfall run-off to cause high BOD levels.

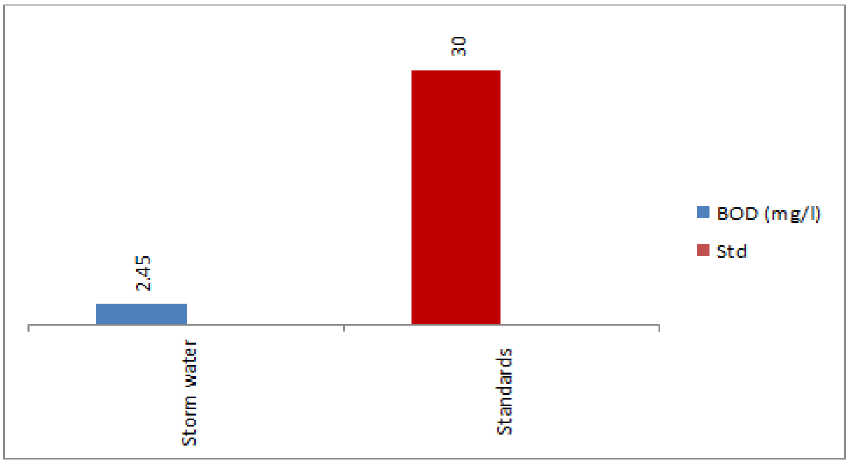


Figure 59: BOD measured of storm water.

5.2.1.11. Chloride

The result of Chloride measured from storm water shows a low-level content of 65.04 mg/l compared to permissible limit of 250mg/l as shown in the figure 60 below. This suggests that the chloride concentrations of the effluent does not have a discernible impact on the surface water quality of any receiving water body and soils.

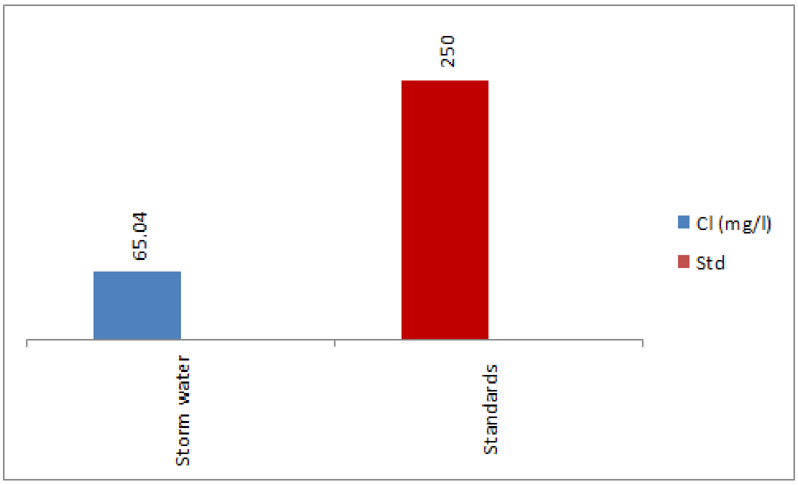


Figure 60: Chloride measured of Storm water.

5.2.1.12. Sulphate

The result of sulphate measured from storm water shows a low-level content of 52 mg/l compared to the permissible limit of 250mg/l as shown in the figure 61 below. This too suggests that the sulphate concentration of the effluent may not have an impact on the surface water quality of any receiving water body and soils.

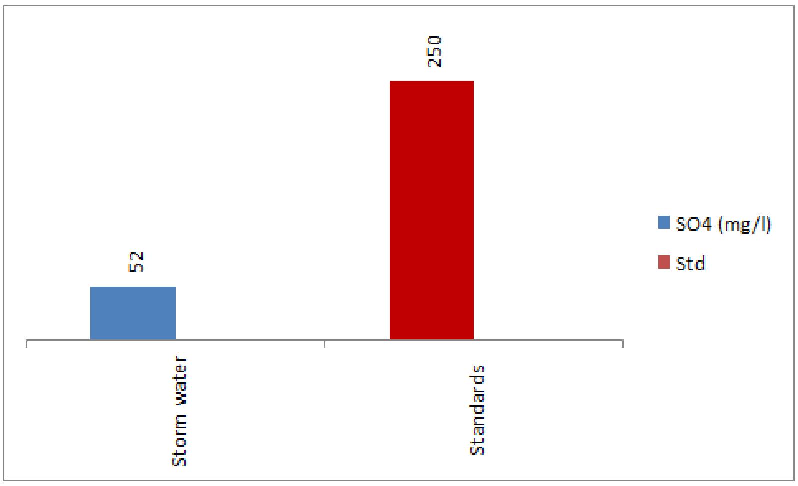


Figure 61: Sulphate measured of storm water.

5.2.1.13. Nitrate Nitrogen

The result of Nitrate Nitrogen measured from storm water shows a low-level content of 2.60 mg/l compared to the permissible limit of 10mg/l as shown in the figure 62 below. This suggests that the nitrate nitrogen concentration of the effluent may not have an impact on the surface water quality of any receiving water body and soils.

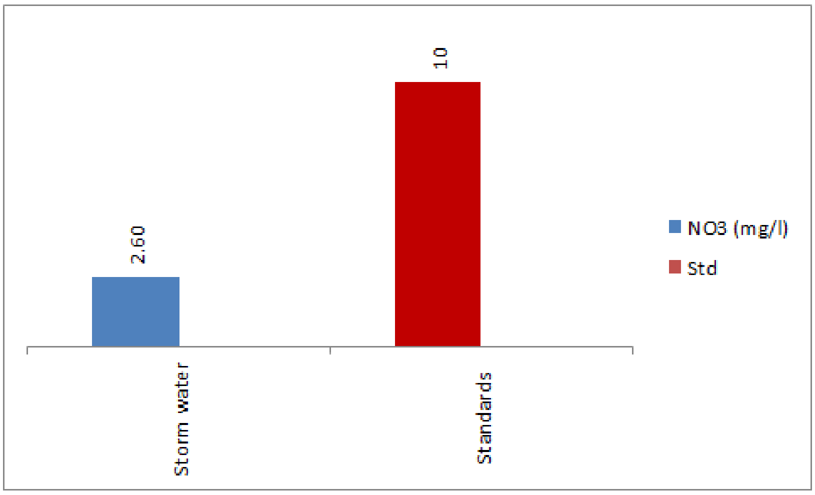


Figure 62: Nitrate Nitrogen measured of storm water.

5.2.1.14. Phosphate

The result of Phosphate measured from storm water shows a low-level content of 3.40 mg/l compared to permissible limits of 5mg/l. This suggests that the phosphate concentration of the effluent may not have an impact on the surface water quality of any receiving water body and soils.

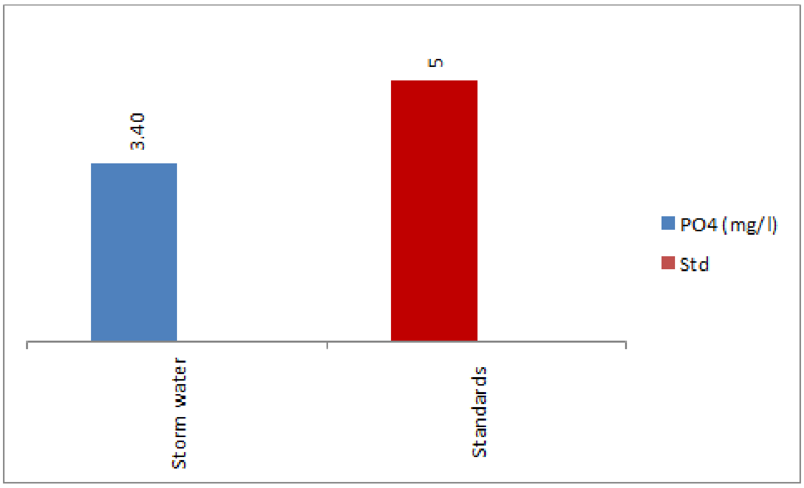


Figure 63: Phosphate measured of storm water.

5.2.1.15. Oil & Grease

The result of Oil &Grease measured from storm water shows there is no oil & grease detected in the storm water sample as presented in the figure 64 below.

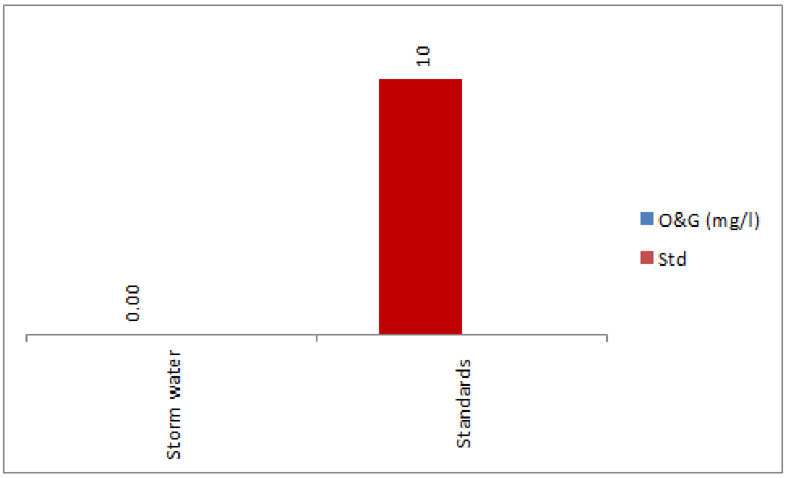


Figure 64: Oil &Grease measured of storm water.

5.2.1.16. Copper

The result of copper (Cu) measured from storm water shows a slightly higher content of 0.133 mg/l than the permissible standard of 0.1mg/l as presented in the figure 65 below, an indication that Cimerwa effluent in the stormwater contributes more Cu quantities than is acceptable to the receiving soils and surface or ground water.

From literature, natural sources of copper in surface water include geological deposits, volcanic activity, and weathering and erosion of rocks and soils. In a similar manner, the Cu content in storm water in the Cimerwa effluent could be from rainfall run-off washing away dust on the ground from stockpiles or crushed raw materials of limestone, sandstone, pozzolana, clay or coal fuel.

According to (Zheng et al., 2004), while copper is a micro- nutrient in soil necessary for proper plant growth, excess copper absorption by plants can lead to decreased root length, root weight, total plant weight, and root to shoot ratio, basically causing stunted growth of crops and hence affect crop productivity in soils of the area that receive this cement effluent.

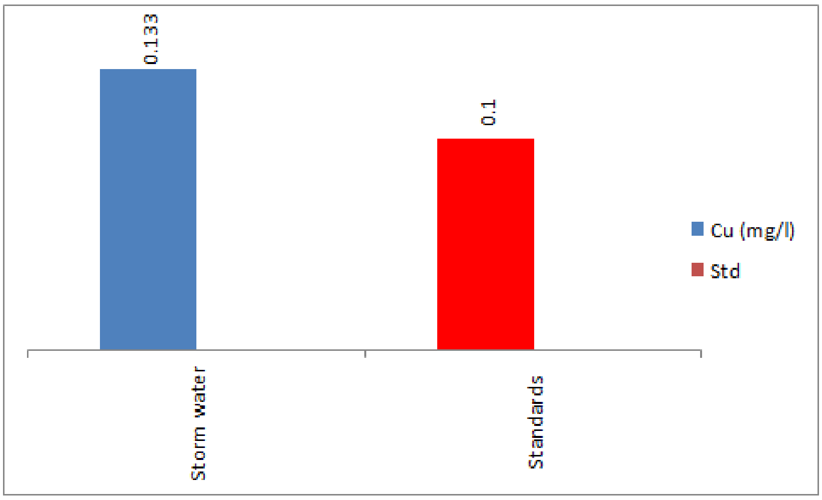


Figure 65: Copper measured of storm water.

5.2.1.17. Cadmium

Cadmium (Cd) levels of the storm water sample shows a high content of 0.394 mg/l in comparison to permissible limit of 0.001mg/l as presented in the figure 66 below. Also, an indication that Cimerwa effluent in the stormwater contributes more Cd quantities than is acceptable to the receiving soils and surface or ground water.

According to the Illinois Department of Public health, one of the sources of Cd is by burning coal or oil that may release cadmium into the air. Once cadmium is in the air, it spreads with the wind and settles onto the ground dust particles and when dust is washed away by rainfall run-off, it dissolves in the run-off water and is discharged as the stormwater effluent as is the case for Cimerwa.

The US EPA 2020 established a Maximum Contaminant Level (MCL) of 0.005 milligrams per litre (mg/l) for cadmium in drinking water. In case cadmium levels are high to gradually pollute soils, ground water and surface waters in the vicinity of the Cimerwa effluent then if the water is used domestically, cadmium has the potential to cause a variety of effects on humans from acute exposures, including nausea, vomiting, diarrhoea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure, as stipulated by US EPA. Furthermore, according to (Association, 2013), Cadmium has the chronic potential to cause kidney, liver, bone and blood damage from long-term exposure at levels above the Maximum Contaminant Level (MCL).

Important to note, is that Cd in water tends to sink and accumulate in bottom sediments, which is important in coming up with a means of treating the cement effluent from Cimerwa to reduce Cd levels ending up in the environment.

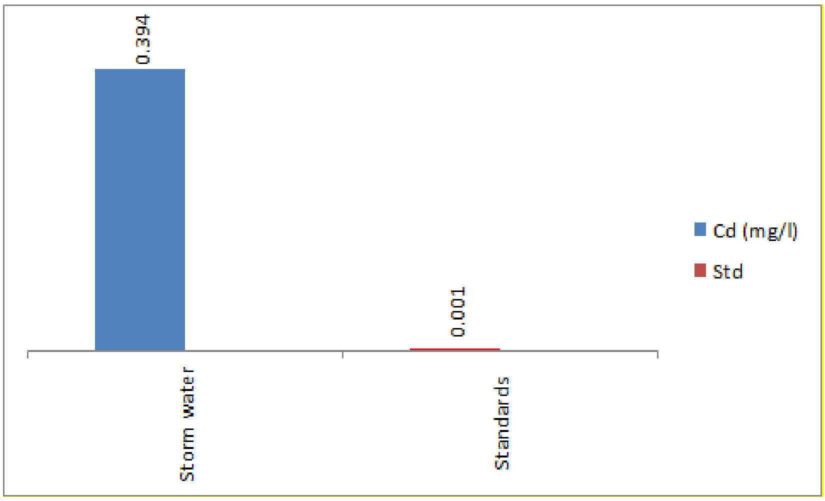


Figure 66: Cadmium measured of storm water.

5.2.1.18. Lead (Pb)

Lead (Pb) levels measured from storm water shows a high content of 0.106 mg/l compared to the permissible standard of 0.01mg/l as shown in the figure 67 below. This implies that Cimerwa cement effluent in the stormwater contributes more Pb quantities than is acceptable to the receiving soils and surface or ground water.

Just like cadmium, according to the New York state Department of health, one of the sources of lead (Pb) is by waste incineration, burning coal or oil that may release lead into the air. Once Pb is in the air, it spreads with the wind and settles on dust on the ground which when washed by rainfall run-off dissolves and is eventually discharged as part of the factory's stormwater effluent as is the case for Cimerwa.

High concentration of the heavy metals such as lead can cause a number of toxic symptoms in plants up taking these heavy metals from polluted soils, toxic symptoms such as retardation in growth (Stunted growth), negative effects on photosynthesis (chlorosis), blackening of roots and different other symptoms.

As for humans, exposure to high levels of lead may cause anaemia, weakness, and kidney and brain damage. Very high lead exposure can cause death. Lead can cross the placental barrier, which means pregnant women who are exposed to lead also expose their unborn child. Lead can damage a developing baby's nervous system.

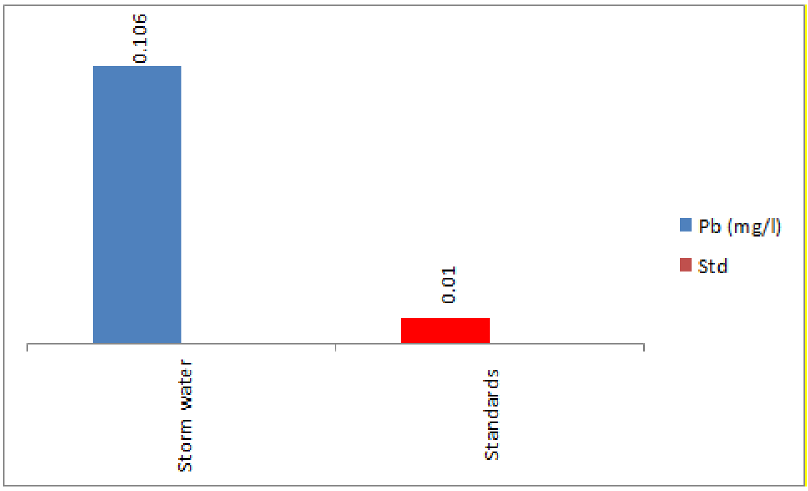


Figure 67: Lead measured of storm water.

5.2.1.19. Zinc (Zn)

The result of zinc measured from storm water shows low content of 0.243 mg/l below the permissible limit of 3mg/l, implying that the Zn concentration of the effluent may not have an impact on the surface water quality of any receiving water body and soils.

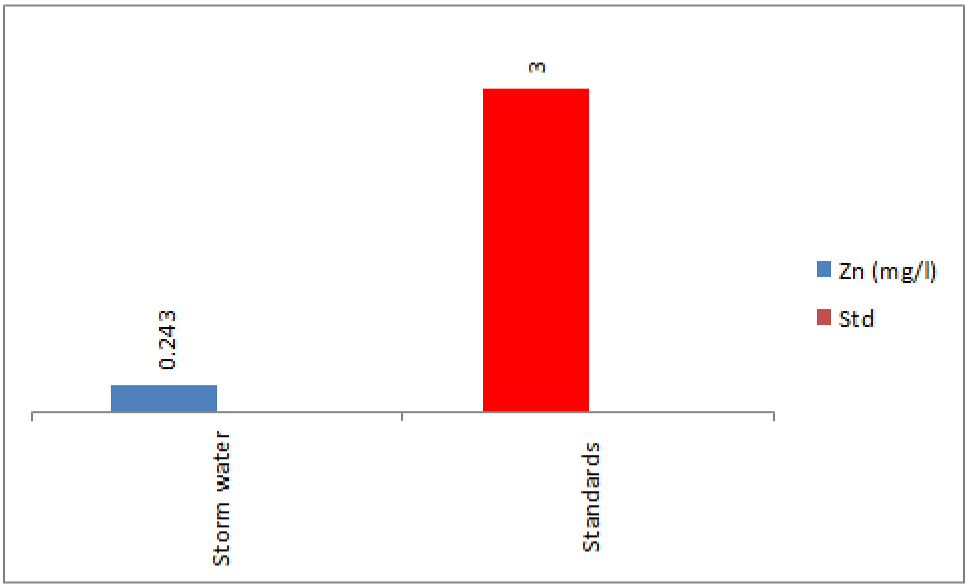


Figure 68: Zinc measured of storm water.

5.3.3. Discussion of sediment quality results

Sediment analysis focused on levels of pollution by four heavy metals: Cadmium (Cd), Copper (Cu), lead (Pb), and Zinc (Zn). The figure 69 below shows results obtained for the four heavy metals against a table 6 summarising the referenced Netherlands' standards for sediment pollution classification as per (Kelderman, et al., 2005).

Based on results from the figure 69 compared for compliance against the referenced standards in table 23, the following interpretation was reached:

- Cadmium (Cd) content (108 mg/kg) was classified under class 4 (heavily polluted sediment ≥12 mg/kg).
- Lead (Pb) content (11.6mg/kg) was classified under class 1 (unpolluted sediment <530 mg/kg).
- While the Copper (Cu) content (21 mg/kg) was classified under class 1 (unpolluted sediment < 35 mg/kg).
- And the Zinc (Zn) content (72.1 mg/kg) was classified under class 1 (unpolluted sediment < 480 mg/kg).

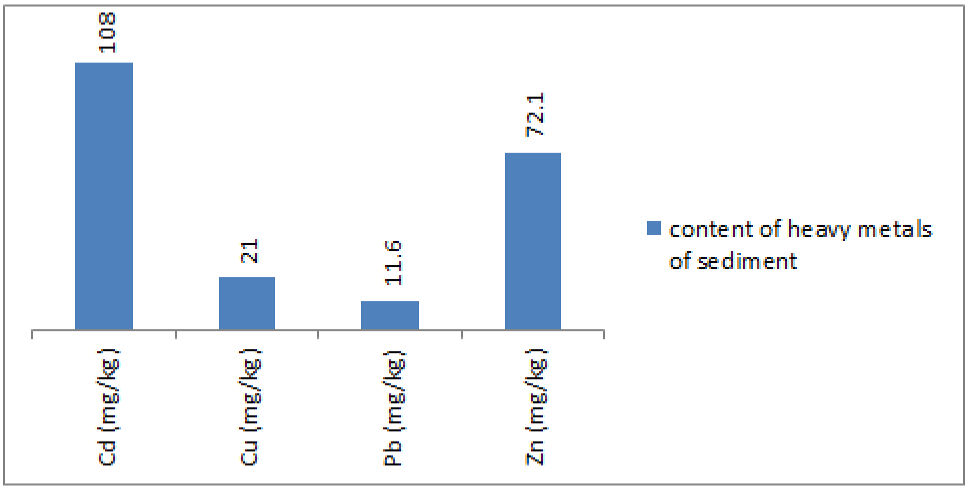


Figure 69: Heavy metal content of Sediment sample

Table 23:Summarised referenced standards for sediment pollution classification

	Class 1	**Class 2**	**Class 3**	**Class 4**
Cd	< 2	2 - < 7.5	7.5 - < 12	> 12
Cu	< 35	35 - < 90	90 - < 190	> 190
Pd	< 530			> 530
Zn	< 480	480 - < 720		> 720

Source: (Kelderman, et al., 2005).

Just as was discussed above in sub-chapter 5.2.3.14 on Cadmium levels in the stormwater sample analysed, the effect of heavily polluted sediment by Cadmium from Cement effluent from Cimerwa could pollute ground water and surface waters in the vicinity of the Cimerwa effluent, which if used domestically, cadmium has the potentially to cause a variety of effects on humans from acute exposures, including nausea, vomiting, diarrhoea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure, as stipulated by US EPA 2020. Furthermore, according to (Association, 2013), Cadmium has the chronic potential to cause kidney, liver, bone and blood damage from long- term exposure at levels above the Maximum Contaminant Level (MCL).

5.4. Environmental Health and safety (EHS) Audit findings

As part of this Environmental Audit (EA), a general understanding of the EHS status of the Industry's internal operations mostly focusing on its EHS performance was assessed against a checklist of criteria referred from the National 2009 Environmental Audit (EA) Guidelines (Appendix I) and 2014 Sector specific EA guidelines (Annex A4). The table below summarises the Industry's EHS status.

Table 24 Environmental Health and safety (EHS) audit findings

Environmental, Health and safety (EHS) Audit criteria checklist	*Expected EHS requirements for the Industry*	*Status at the New Cimerwa factory*	*Shortcomings against EHS Audit criteria*
Environmental protection initiatives	Environmental protection by virtue of the Industry's activities or its own initiatives	The Factory has implemented the following initiatives towards environmental protection: • Use of bag house filters for treating dust from Stack emissions. • Reduction of carbon footprint of cement production and depletion of natural resources in raw material by use of Pozzolana and Fly Ash waste from Gishoma and Hakan-Yumn power plants as filler in cement production as a means of reducing quantity of Clinker in the final cement product. • Natural Resource Depletion Control are in place such as recycling water for cooling, recycling air for pre-heating to reduce on fuels used, use of alternative fuels to reduce on the coal fuel imported. • Implementation of Environmental Management System (EMS) as part of the Integrated management system (IMS) to enhance environmental performance. • Monitoring equipment are in place e.g., on line gas analyzers and noise meters. • Provide adequately PPE for workers' safety such as ear plugs, dust masks, eye goggles, helmets, boots, reflector jackets.	No shortcomings.

Environmental, Health and safety (EHS) Audit criteria checklist	Expected EHS requirements for the Industry	Status at the New Cimerwa factory	Shortcomings against EHS Audit criteria
		• The organization has also documented Environmental Aspects and Impacts Register of each activity of cement production from mining to cement product distribution. • Tree Planting programs are supported annually. e.g., 2018 planted 3,3000 trees species, 2019 and 2020 planted 16400 tree species. Areas where trees were reported to have been planted comprise of; inside the factory, around the factory, at CIMERWA school, quarry areas of Amashyuza, Ssndastone Kibangira quarry and clay quarry, and rehabilitation of Nengo quarry currently ongoing as the quarry is closed now. • Zero Waste disposal program is implemented which involves; recycling waste generated and plastics, papers, bags and others of the same type are burned into the Kiln. • E-waste is sent for recycling to Bugesera E-waste recycling Plant. • Scraps are solid for reuse. • All wastes generated are contained in waste designated areas. • Use of single use plastic bottles was replaced by 20L gallons and still water bottles. • Burning of PCB contaminated oils into kiln- In the region only CIMERWA accredited by UNDP and REMA to burn these Oils. • Installation of Water meters to monitor water consumption in line with Climate changes management. • Installation of Continuous Emission monitors at stack. • Purchase of Ambient Monitors to monitor community exposure to Dust. • Monitoring compliance with EIA obligations. • Preparing for and candidate to EMS/IMS certification.	

Environmental, Health and safety (EHS) Audit criteria checklist	***Expected EHS requirements for the Industry***	***Status at the New Cimerwa factory***	***Shortcomings against EHS Audit criteria***

EMP or EMS or Environmental Policy Implementation	Possession of an EMP or EMS or Environmental Policy.
	Understanding and implementation of the EMS or EMP or policy.
		• The factory is currently implementing the ISO 14001: 2015 Environmental Management Systems (EMS).
		• The organization has documented an environmental policy in line with IMS.
		• By implementing the EMS, the factory has identified significant aspects and impacts as documented in the environment aspect and mitigation register.
		• In compliance to the environmental Law no.48/2018 of 2018, Cimerwa had in the past obtained an EIA certificate in 2009 with conditions of approval for an ESMP prepared for establishment of the new cement factory. However, while Cimerwa has complied to a number of measures proposed in the conditions of approval and mitigation measures during operation phase of Cimerwa proposed in the (CIMERWA, 2009) ESMP, the following proposed mitigation measures are still inadequate:
		  o Minimizing on effects of fugitive dust emissions by covering open areas within the plant premises and a green belt along the boundaries of the plant premises.
		  o For noise suppression, Cimerwa was meant to provide plantations in and around the plant premises, earth mounds and plantations in the zone between plant and township would further attenuate noise in the residential area.
		  o Put in place extensive vibration monitoring system to check and reduce vibrations. Vibration isolators needed to be provided to reduce vibration and noise wherever possible.
		  o Treated effluent was proposed for use for dust suppression and plantation/greenbelt development.
			Shortcomings observed.
			Some of the mitigation measures of the 2009 ESMP for the new factory were not fully implemented as mentioned in the status at the new Cimerwa factory.

Environmental, Health and safety (EHS) Audit criteria checklist	***Expected EHS requirements for the Industry***	***Status at the New Cimerwa factory***	***Shortcomings against EHS Audit criteria***
		○ Appropriate storm water and runoff control systems to be provided to minimize the quantities of suspended material carried off site.	
Wastewater management	Presence of a collection, treatment and discharge system. Wastewater quality records of regular monitoring of treatment system.	• The existing wastewater treatment systems are septic tanks, as primary treatment. While wastewater quality monitoring was not conducted, considering the BOD levels from stormwater analysis were within permissible levels, the septic tank system could suffice to be treating black and grey wastewater. • Cimerwa currently has a contract with INES Ruhengeri for its wastewater analysis, which has shown compliance currently and in the past. • It is also important to note that the new factory applies a dry cement production process implying water use is at a minimum.	No significant short coming. The septic tank might be sufficient since it is it is a dry cement product process that does not use or require a lot of water.
Energy management	Energy saving initiatives implemented. Records of energy savings over time.	Factory initiatives towards saving energy comprise: • By recycling hot air from the clinker cooler/kiln for reuse in the cyclone preheaters, the factory saves on energy required at the pre-heating raw meal. • Use of Solar panels at the staff residences for heating water. • Use of Energy saving lights at the factory. • The factory monitors and records energy consumption daily with a purpose to reduce energy consumption.	Energy saving initiatives observed. No shortcomings.
Solid waste management	Presence of habit of sorting, recycling, reuse, treatment of likely solid	• Organic solid waste is collected by a RURA approved waste handler.	Solid waste management

Environmental, Health and safety (EHS) Audit criteria checklist	*Expected EHS requirements for the Industry*	*Status at the New Cimerwa factory*	*Shortcomings against EHS Audit criteria*
	waste before proper disposal of non-recyclable waste.	• All other solid waste is controlled onsite in designated areas and burned into the Kiln. • There is a waste Management procedure in place that emphasizes the 3Rs (reduce, reuse, recycle). • It has enforced Housekeeping program to minimize, reuse and recycle waste.	procedure in place and implemented. No shortcomings.
Air quality monitoring and control	Air quality monitoring and records of performance on emissions control.	• Stack emissions for dust particulate matter, NOx, CO_2 are periodically monitored and measurements recorded for comparison to permissible limits and shared monthly with REMA. • Ambient air quality monitoring in and outside of the factory premises are not monitored.	No record of ambient air monitoring done.
Noise and vibration monitoring and control	Noise and vibration control mechanisms on site. Protective measures to workers and public. Noise level monitoring and records keeping of monitoring.	• Workers are adequately equipped with ear plugs, trained on how to use them and their importance and enforced. • Documentation available on noise monitoring is of an occupational noise survey of Cimerwa in conjunction with RSB done in May 2019 ((RSB), 2019). Data from this noise survey, showed compliance towards permissible noise levels by national and international standards, except for areas in the raw mill, coal mill, cement mill and end of the kiln near the cooler. Recommendations were given by RSB to Cimerwa on what measures to take mitigate effects of exposure to occupational noise, which included; carrying out noise mapping, an independent risk assessment on noise exposure time, noise reduction techniques, managing workers' exposure to noise within acceptable limits, hearing	Short comings were observed by the noise survey as inadequacy in noise mapping, independent risk assessment of noise exposure time, regular noise measurements to the neighbourhood.

Environmental, Health and safety (EHS) Audit criteria checklist	***Expected EHS requirements for the Industry***	***Status at the New Cimerwa factory***	***Shortcomings against EHS Audit criteria***
		protection, ensure equipment is maintained and workers are trained on noise risk management.	
Firefighting preparedness	Firefighting management plan. Firefighting equipment, fire escape plans, assembly points, emergency numbers. Fire drills and trainings to workers. Records of these drills and trainings. Records of fire incidences and how they were handled.	On the factory premises, firefighting preparedness is evident by the following: • Fire risk self-assessment is done for all departments of Cimerwa, most recently in February 2021. • Fire extinguishers onsite. • Water hydrants. • Fire foams. • Sand buckets. • Mobile water tank trucks for fire fighting. • Trainings and Fire drills conducted. • CO_2 in Coal mill. • Fire alarm and detectors.	No short comings.
Emergence Response preparedness (ERP)	Emergence response preparedness plan. Staff awareness and trainings on this plan's implementation. Records keeping of these trainings and drills.	• Procedure for Emergency Preparedness and Response (CIMR/SHERQ/PRO/05) is in place. • Cimerwa PLC has identified the following Potential Emergency situations and incidents; Explosions, fires, structure Collapse, traffic Accidents, critical equipment failure, Oil spillages, Ground Water and Land Contamination, Disease Outbreak, Hot Material Rush, Labour Unrest, Terrorist Attack, Lightening, Floods, Landslides (Mines). • Existing measures include:	No shortcomings.

Environmental, Health and safety (EHS) Audit criteria checklist	***Expected EHS requirements for the Industry***	***Status at the New Cimerwa factory***	***Shortcomings against EHS Audit criteria***
		o An Emergency response procedure exist. o Ambulance available onsite. o First aiders trained and available onsite. o Implement and Monitor BCP (Business Continuity Program). o Partnership with Local and Key Health service institutions.	
Occupation Health and safety (OHS)	Existence of Health Safety Environment (HSE) policy. Health and safety awareness of workers and visitors on site. OHS committees existing and implementing the HSE policy, objectives, setting targets and meeting them. Personal Protective Equipment (PPE) worn by workers. Records keeping of near misses, incidences, accidents and fatal accidents on site.	The organization is in the process of implementing ISO 45001:2018. The following procedures are in place, for some already under implementation and some in final drafting: • CIMR_SHERQ_SOP_01 SOP for Operating and Use of Parking. • CIMR_SHERQ_SOP_02 SOP for Permit to Work. • CIMR_SHERQ_SOP_03 SOP for Contractor Safety Management. • CIMR_SHERQ_SOP_04 Drugs and Alcohol Policy. • CIMR_SHERQ_SOP_05 Electrical Safety Standard. • CIMR_SHERQ_SOP_07 SOP for Control of Hazards Associated with Noise. • CIMR_SHERQ_SOP_08 SOP for Management of Return to Work. The organization has also documented Occupational Health and Safety (OHS) Risks Registers: • OHS Procedures are in place. • Training and awareness to employees to impart a safety culture is regularly done.	No shortcomings.

Environmental, Health and safety (EHS) Audit criteria checklist	***Expected EHS requirements for the Industry***	***Status at the New Cimerwa factory***	***Shortcomings against EHS Audit criteria***
Staff safety awareness trainings	Safety awareness trainings performed regularly. Record keeping of these trainings.	• Onsite safety audits and inspections are done. • Annual health assessment program for Employees (Respiratory, visual, ergonomics) and checking employee medical fitness is performed. • 100% health insurance to employee and 85% insurance for legal dependents. • Company has an equipped Clinic with qualified Doctor and Nurses. • Snakes and hazards program in place to create a safety culture. • Incident reporting and more focus on near misses is implemented. • They exercise a program of mosquito, vector control and fumigation. • Cimerwa Plc is currently a candidate to ISO 45001;2018/ IMS certification process.	No shortcomings.
Response to public inquiries and complaints	Existence of mechanism of collecting inquiries, complaints from the public and responding to them.	• Procedure for Communication, Participation and Consultation (CIMR/PRO/SHERQ/03) has been documented in line with ISO 14001: 2015 and ISO 45001: 2018 standards. Responses are mainly through: o Through quarterly organized meetings. o Physical engagements and visiting. o Official writings and communications.	No shortcomings.

5.5. Summary of non-conformities and their impacts

Non-conformities are summarized in the table below, with observations of why there were non-conformities and likely impacts of the non-conformities.

Table 25 Non-conformities and impacts

Parameters	Non-conformities for the Industry	Observations why non-conformities	Impact of non-conformities
Ambient dust and noise			
Ambient dust	Even though results from the short period of ambient dust monitoring by this audit when compared to national standards might not be conclusive reference, the higher PM_{10} and $PM_{2.5}$ levels of other sites compared to the baseline site in this audit's analysis show that other sites were subjected to more impact than the baseline by virtue of proximity to Cimerwa. For areas along the road from the quarry, areas less than 150m from the road are the most polluted by the larger dust particulates of PM_{10} when in comparison to the uninfluenced baseline site.	Fugitive dusts blown by winds from the concrete floors of Cimerwa towards neighbouring communities, possibility of unusual incidences of dust emission, mobile crusher dust emissions. Dust pollution from the road to the quarry is due to the unpaved road, plus trucks exceeding speed limits set by Cimerwa as a mitigation measure to reduce dust from the road and possibly trucks transporting uncovered raw material.	Inconvenience to the normal livelihood of neighbouring communities in the sense of not being able to dry harvest out and collect clean rainwater due to dust deposits. Possible respiratory health issues to the families living in the vicinity of the industry, emerging from the industry's dust emissions.
Noise	Noise levels are above the permissible residential and silence zone standards for most sites outside the factory boundaries,	Non- compliance was mainly due to comparison of measured noise levels against residential noise standards which are lower than the Industrial	Noise nuisance to most of the neighbourhood resulting in continuous conflict between Cimerwa and neighbouring communities.

Parameters	Non-conformities for the Industry	Observations why non-conformities	Impact of non-conformities
	except at the baseline site (N1) which is lower in elevation than the factory and two sites within the factory premises (N4 and N5), which are inside the factory as a more permissive industrial standard is applied for them.	noise standards and also night residential standards which drop compared to during day residential standards. The reason for applying residential standards in addition to industrial standards was to understand the factory noise impact to neighbouring residents and also since the area is still zoned under residential.	
Water quality and sediment pollution			
pH	pH of stormwater sample was at 11.76 above the permissible limit of pH 8.5.	According to (Ipeaiyeda & Obaje, 2017), high pH levels of cement effluent could be a result of the reaction process of calcium carbonate ($CaCO_3$), aluminum oxide (Al_2O_3), silica oxide (SiO_2) and iron oxide (Fe_2O_3) in clinker and cement production, meaning cement effluent having a high alkalinity.	High pH effluent levels could cause plant's soil pH to increase, which disrupts the plant's ability to absorb certain nutrients, like iron, thereby causing plant's leaves to become yellow between the veins, a sign of iron deficiency. Also, at a high pH, soil builds up toxic levels of certain nutrients. For instance, molybdenum soil levels increase in a high pH environment. High pH levels in waters can damage gills and skin of aquatic organisms and cause death at levels over 10.0. Most fish cannot tolerate high pH levels (up to 9.5). Death can occur even at typical levels (9.0) if ammonia is present in the water.
Conductivity	Conductivity of the stormwater sample was at 2710 µS/cm beyond the permissible limit by	This high conductivity is an indication of high ions concentration and high dissolved solids (TDS) of chemicals and minerals present in the water.	High conductivity hinders plant nutrient uptake in soils by increasing the osmotic pressure of the nutrient solution, wastes nutrients meant for the plants, thereby increasing nutrients discharged into the

Parameters	Non-conformities for the Industry	Observations why non-conformities	Impact of non-conformities
	National standard of 1000 µS/cm.		environment and hence contributing towards environmental pollution. For aquatic organisms in receiving water bodies, high conductivity implies high saltiness of the water, which could stress fish and other aquatic organisms that don't tolerate high increases of saltiness in water.
Total Dissolved Solids (TDS)	TDS levels of the stormwater sample was at 1482 mg/l beyond the permissible limit by National standard of 500mg/l.	The high TDS is a result of high impurities (minerals and chemicals) in the water from dust of cement, coal, limestone, sandstone and pozzolana raw material.	High TDS, turbidity and TSS levels of the stormwater effluent is the probable reason for the quick filling up of pits excavated to collect and hold discharged cement effluent at the Nyenyeri village boundary wall. High TDS, turbid and TSS effluent could also interfere with receiving water streams downhill that feed into water bodies farther on such as Rubyiro river and streams in Bugarama rice wetland, by reducing sunlight penetration which may affect food supplies and growth of aquatic organism.
Turbidity	Turbidity levels of the stormwater sample was at 575 NTU above the permissible limit of 5NTU.	According to (Ipeaiyeda & Obaje, 2017), such high turbidity levels of the Cimerwa effluent could have originated from dissolved dust and solids from the crushing of raw material, kiln and the packing area.	
Total Suspended Solids (TSS)	TSS levels of the sample analysed was 200 mg/higher than the permissible limits of 30mg/l.	This high TSS can also be explained by the dust and solids washed by run-off from raw material sheds and crushers of limestone, sandstone, pozzolana, coal, cement dust from concrete floors.	
Chemical Oxygen Demand (COD)	COD levels of the stormwater was 304 mg/l above the permissible limit of 50mg/l.	As observed by (Ipeaiyeda & Obaje, 2017), a high COD in the stormwater is an indication of gross chemical load of the effluent resulting from reaction processes of calcium carbonate	High COD level implies a high amount of chemically oxidizable organic material in the sample, which will reduce dissolved oxygen (DO) levels in receiving waters. A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life

Parameters	Non-conformities for the Industry	Observations why non-conformities	Impact of non-conformities
		($CaCO_3$), aluminum oxide (Al_2O_3), silica oxide (SiO_2) and iron oxide (Fe_2O_3) as raw materials for cement production.	forms for any receiving water streams that feed into the likes of Rubyiro River farther on.
Copper (Cu)	Cu level of the stormwater was at 0.133 mg/l slightly above the permissible standard of 0.1mg/l.	Cu content in storm water in the Cimerwa effluent could be from rainfall run-off coming in contact with stockpiles or crushed raw materials of limestone, sandstone, pozzolana, clay or coal fuels mined from geological deposits, volcanic regions and eroded rocks.	According to (Zheng et al., 2004), while copper is a micro- nutrient in soil necessary for proper plant growth, excess copper absorption by plants can lead to decreased root length, root weight, total plant weight, and root to shoot ratio, basically causing stunted growth of crops and hence affect crop productivity in soils that receive this cement effluent.
Cadmium (Cd)	Cd level for the stormwater was 0.394 mg/l above the permissible limit of 0.001mg/l. As for sediment sample analysed, Cd content was at 108 mg/kg, classified under class 4 of heavily polluted sediment (≥12 mg/kg).	According to the Illinois Department of Public health, one of the sources of Cd is by burning coal or oil that may release cadmium into the air. As is the case for Cimerwa, once cadmium is in the air from burning coal, it spreads with the wind and settles onto the ground or surface water as dust, thereby dissolving in surface water when washed away by the rainfall run-off.	The US EPA 2020 established a Maximum Contaminant Level (MCL) of 0.005 milligrams per litre (mg/l) for cadmium in drinking water. In case cadmium levels are high to gradually pollute soils, ground water and surface waters in the vicinity of the Cimerwa effluent then if the water is used domestically, cadmium has the potentially to cause a variety of effects to humans from acute exposures, including nausea, vomiting, diarrhoea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure, as stipulated by US EPA. Furthermore, according to (Association, 2013), Cadmium has the chronic potential to cause kidney, liver, bone and blood damage from long- term

Parameters	Non-conformities for the Industry	Observations why non-conformities	Impact of non-conformities
			exposure at levels above the Maximum Contaminant Level (MCL).
Lead (Pb)	Pb levels of the water samples was 0.106 mg/l, high compared to permissible standard of 0.01mg/l.	Just like cadmium, according to the New York state Department of health, one of the sources of lead (Pb) is by waste incineration, burning coal or oil that may release lead into the air. As is the case of Cimerwa, once Pb is in the air, it spreads with the wind and settles on dust which when washed by rainfall run-off dissolves and eventually discharged to receiving soils.	High concentration of the heavy metals such as lead can cause a number of toxic symptoms in plants uptaking these heavy metals, toxic symptoms such as retardation in growth (Stunted growth), negative effects on photosynthesis (chlorosis), blackening of roots and different other symptoms. As for humans, exposure to high levels of lead may cause anemia, weakness, and kidney and brain damage. Very high lead exposure can cause death. Lead can cross the placental barrier, which means pregnant women who are exposed to lead also expose their unborn child. Lead can damage a developing baby's nervous system.
Public consultation issues			
Impact of industrial activity on livelihoods of neighbouring communities of Nyenyeri and Kabarore villages.	Issues raised by both village residents are: • Loud Noise mostly from the crushers and ball mills. • Dust mostly from cement and coal blown by wind in their direction, getting worse during the dry season. Dust deposits were evident on house roofs, leaves of trees for households close by and claims of coal	The Occupational noise survey done in May 2019 for Cimerwa by RSB showed non-compliance of noise generated from the raw mill, coal mill, coal bins, cement mill, kiln and cement silos. In addition to this, the Cimerwa Environmental aspects and impacts register of 2019, shows vibrations as an aspect worth observing from the same areas mentioned above.	Discomfort of homes from high noise levels at night affecting their sleep, livelihood and allowing thieves to steal undetected, especially for Nyenyeri village. Possible respiratory health issues to the families living in the vicinity of the industry, emerging from the industry's dust emissions. Black polluted water harvested off the roofs of neighbouring communities during the rain season is unbearable for usage and potentially a health hazard to those that use it.

Parameters	Non-conformities for the Industry	Observations why non-conformities	Impact of non-conformities
	dust causing black rain harvested water and respiratory distress from dust. • Storm water from CIMERWA had in the past destroyed few houses. Three houses were affected by a combination of storm water from CIMERWA and surrounding hill but did not affect the whole village.	Cracks on walls of houses close to the factory boundary were observed during the Auditor's field visit, possibly from machine vibrations. Dust deposits were evident on house roofs, leaves of trees for households close by.	Flooding of some homes in Nyenyeri village, partly from stormwater discharged by Cimerwa.
Suitability of the industry's Location	Muganza sector, shara cell, Nyenyeri and Kabarore villages in which Cement Plc is located, has no area master plan and is still considered as a residential zone "Imiturire" even though Cimerwa existed before many of the settlements neighbouring it.	Cimerwa existed before many of the settlements neighbouring and most of the communities have developed around it due to existence and activities of Cimerwa. Delays in preparation of a master plan for this area by the District, creates competing conflict between residential and Industrial requirements.	Dust, noise and vibration emissions and stormwater effects will continue to be a source of conflict between Cimerwa and the neighbouring community.
Industrial buffer from sensitive areas. e.g. residentials	Inadequate or rather no buffer zone between the industry and the residential communities. Some residents are less than 8m from the Industry wall fence on the side of Nyenyeri village, while others are within the 200m radius from the Industry.	The industry existed at its location before a number of these settlements existed, before the development of the health protection zone by the Urban planning Code of 2019 and the chimney buffer distance from the 2017 Rwanda National land use planning guideline and therefore the	Dust, noise and vibration emissions and stormwater effects will continue to be a source of conflict between Cimerwa and the neighbouring community.

Parameters	Non-conformities for the Industry	Observations why non-conformities	Impact of non-conformities
		reason for no buffer zone between the industry and the residences. Furthermore, the new factory was built on Cimerwa land, closer to the Nyenyeri community compared to the Old factory, hence the probable reason of impact due to proximity.	
Environment Health and safety (EHS) parameters			
EMP or EMS or Environmental Policy Implementation	While Cimerwa has complied to a number of mitigation measures proposed in the conditions of approval proposed in the 2009 ESMP, the following proposed mitigation measures are still inadequate: • green belt along the boundaries of the plant premises to minimize effects of fugitive dust emissions. • For noise suppression, Cimerwa was meant to provide plantations in and around the plant premises, earth mounds and plantations in the zone between the plant and township to further attenuate noise to the residential area.	No buffer zone and green belt along the Cimerwa's boundary exists on sides of the residential communities neighbouring the Industry as mitigation measures to minimizing dust, noise and vibration effects.	Without implementing these proposed mitigation measures, dust, noise and vibration emissions and stormwater, will continue to be a source of conflict with the neighbouring community.

Parameters	Non-conformities for the Industry	Observations why non-conformities	Impact of non-conformities
	• Putting in place extensive vibration monitoring system to check and reduce vibrations. Vibration isolators in place to reduce vibration and noise wherever possible. • Using treated effluent for dust suppression and plantation/ greenbelt development. • Providing appropriate storm water and runoff control systems to minimize the quantities of suspended material carried off site.		
Air quality monitoring and control	Ambient air quality monitoring in and outside of the factory premises are not monitored.	Records from Cimerwa Plc show only stack emission measurements and no ambient air quality in and outside the factory to determine impact of fugitive dust and gases to the environment.	Stack emissions are not sufficient. Without ambient air quality measurements in and outside the factory, the factory misses out on reference scientifically evidenced data for guidance in improving its environmental performance later on used to defend its position of emission impacts to the environment.
Noise monitoring and control	Non-compliance to national and international standards of noise/sounds levels specific to the areas of the raw mill, coal mill, cement mill and end of the kiln near the cooler, as observed by the ((RSB), 2019)-Cimerwa occupational noise survey.	Noise level monitoring and record keeping is not done to determine whether exposure for workers is suitable and whether noise emission to the surroundings is compliant.	Long exposure of workers to noise could result in deafness/ hearing loss. Without implementing noise monitoring and implementing relevant mitigation measures to suppressing noise and vibration emissions, these will continue to be a source of conflict with the neighbouring community.

Parameters	Non-conformities for the Industry	Observations why non-conformities	Impact of non-conformities
	Other than this survey, there were no records of noise levels monitored on premises and its noise impact on the neighbourhood.		

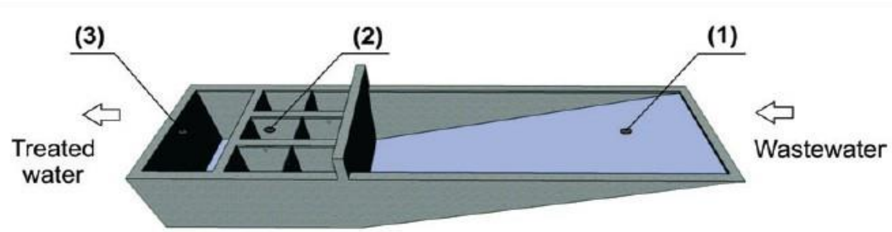
6 CORRECTIVE ACTIONS

The purpose of a corrective actions plan is to identify and respond to non-conformities through proposed actions or measures.
In the tables that follow, a corrective action plan was presented in a manner that indicates actions implementable by the industry on a short-term, medium-term and long-term basis.

Table 26: Corrective Action Plan for short-term measures

Parameters	Non-conformities for the Industry	Corrective Actions proposed	Planned time for implementation of Actions
Air and noise quality			
Ambient dust	The higher PM_{10} and $PM_{2.5}$ levels of sites neighbouring the factory compared to the baseline site in this audit's analysis show that other sites were subjected to relatively higher dust levels than the baseline by virtue of proximity to Cimerwa. For areas along the road from the quarry, areas less than 150m from the road are the most polluted by the larger dust particulates of PM_{10} when in comparison to the uninfluenced baseline site.	First of all, the issue of zoning of the area between Industrial and residential needs to be discussed and resolved by Rusizi District. This will rectify the compliance requirements of the factory from residential to only Industrial standard requirements and minimize the increment in settlements closer to the factory. Considering that the factory has in place most of the requirements to control dust emissions (including bag filters) and considering also that any cement factory by virtue of its activities, handles a lot of dust, diffuse dust emissions and incidental emissions are unavoidable. A sustainable technical solution that could completely mitigate dust and noise emissions from the factory is unlikely. It is, therefore, recommended that a green belt buffer zone be established between the factory and closest resident that is at least 500m radius from the main chimney, based on the recommendation of 500m from the industry chimney from 2017 Rwanda National land use planning guidelines and the distance of dust level exposure of neighbouring community compared to the study baseline site.	• Immediate action for all actions except paving the road.

Parameters	Non-conformities for the Industry	Corrective Actions proposed	Planned time for implementation of Actions
		This buffer zone may be approached by freezing new constructions first, and gradually resettling the existing residents starting by the most exposed to industrial dust and noise pollution of Nyenyeri community. To minimize dust pollution along the Amashyuza quarry road, the following actions are proposed: • Continuous water spraying of the road to reduce dust raised. • To slow down trucks that raise dust, measures should be put in place by Cimerwa in collaboration with local authorities and police. Such measures comprise; enforcing speed limit by inserting speed governors in trucks, speed limits along the road more enforced, humps placed along the road. • Since the road to the quarry is a public road, the local authorities together with Cimerwa may embark on a tree planting in the accepted 12m class 2 road reserve of this public road to serve as suppress dust from the road traffic. Furthermore, local authorities will also endeavour to avoid settlements within the road reserve. • Consider paving the road with asphalt.	
Noise	Noise levels are above the permissible residential and silence zone standards for most sites outside the factory boundaries, except at the baseline site (N1) which is lower in elevation than the factory and two sites within the factory premises (N4	• According to (USDoL, 2013), installation of noise mufflers/silencers in the high noise emitters. i.e. the mills and crushers, could reduce noise emissions. Once installed, mufflers must be cleaned on a regular basis to be effective at reducing noise, otherwise, they actually can increase noise levels. • The Audit proposal to establish a 500m buffer zone from the chimney around the factory mentioned above, is again supported by the results of	In 1-2 years

Parameters	Non-conformities for the Industry	Corrective Actions proposed	Planned time for implementation of Actions
	and N5), which are inside the factory as a more permissive industrial standard is applied for them.	ambient noise variation with distance from the factory in figure 39 above, where acceptable noise levels were obtained at 500 m from the factory. • The buffer zone once in place can be planted as a green belt with trees and plants to suppress noise.	
Water and sediment quality			
pH	pH of stormwater sample was at 11.76 above the permissible limit of pH 8.5.	Reference to (H.M.Paula & M.S.O Ilhla, 2014), sedimentation settling tanks of form in the figure below, can be used as a wastewater treatment system for treating of cement water effluent to levels permissible for discharge to the environment but also to hold water and regulate its flow hence avoiding flooding. With this system, alkaline pH levels could be corrected to permissible levels by acidification, turbidity can be corrected by additional chemical coagulation with reagents such as such as aluminum sulphate and ferric chloride. By settling, heavy metals attached to the sediment at the bottom of the chambers can be removed along with the sediment.  	Within 1-2 years for the settlement settling tanks design, construction and operation to be completed.
Conductivity	Conductivity of the stormwater sample was at 2710 μS/cm beyond the permissible limit by National standard of 1000 μS/cm.		
Total Dissolved Solids (TDS)	TDS levels of the stormwater sample was at 1482 mg/l beyond the permissible limit by National standard of 500mg/l.		
Turbidity	Turbidity levels of the stormwater sample was at 575 NTU above the permissible limit of 5NTU.		
Total Suspended Solids (TSS)	TSS levels of the sample analysed was 200 mg/higher than the permissible limits of 30mg/l.		

Parameters	**Non-conformities for the Industry**	**Corrective Actions proposed**	**Planned time for implementation of Actions**
Chemical Oxygen Demand (COD)	COD levels of the stormwater was 304 mg/l above the permissible limit of 50mg/l.	*1-Stormwater inlet chamber as Cimerwa discharge point.* *2-Intermediate decanting chambers.* *3-Outlet chamber.* Also applying phytoextraction or phytoremediation technique of introducing plants to uptake heavy metals could contribute to the efficiency of the proposed sedimentation tank treatment system of cement effluent. Dry plant leaves of thyme, sage, banana, mint, anise and oleander plants have been used for removing lead, cadmium, cooper and zinc ions for aqueous solutions. Furthermore, in reference to (J.R.Pan, et al., 2004), sludge from the settlement tanks can be recycled in cement industry by reusing it as raw material for cement. In most cases, this sludge is virtually non-hazardous, chemical composition of the inorganic sludge is similar to the clay used in cement producing. Reusing the sludge from the sedimentation tank system as a raw material in cement production should be a practical approach, after dewatering it. However, the limiting factor of recycled sludge in cement process is chemical composition of sludge to meet required element compositions to contribute to cement composition, which could be analysed by the Quality Assurance department of Cimerwa before recycling it.	
Copper (Cu)	Cu level of the stormwater was at 0.133 mg/l slightly above the permissible standard of 0.1mg/l.		
Cadmium (Cd)	Cd level for the stormwater was 0.394 mg/l above the permissible limit of 0.001mg/l. As for sediment sample analysed, Cd content was at 108 mg/kg, classified under class 4 of heavily polluted sediment (≥12 mg/kg).		
Lead (Pb)	Pb levels of the water samples was 0.106 mg/l, high compared to permissible standard of 0.01mg/l.		

Parameters	Non-conformities for the Industry	Corrective Actions proposed	Planned time for implementation of Actions
		While sludge is reused as a raw material for cement production, effluent water from sedimentation settling tank could be used for irrigating the green belt in the proposed buffer along the boundary wall. As a form of self-evaluation, Cimerwa could regularly take water quality monitoring for influent and effluent from the sedimentation tank system to determine its treatment efficiency and show the Industry's conformity to surface water effluent discharge.	
Public social responsibility			
Suitability of the industry's Location	Muganza cell, Nyenyeri and Kabarore villages in which Cement Plc is located, has no area master plan and is still considered as a residential zone "Imiturire" even though Cimerwa existed before many of the settlements neighbouring it.	• Rusizi District to consider preparing a master plan for this area by zoning it to avoid conflicts between resident communities and Cimerwa Plc over eligible land use of this area between residential and industrial.	Immediate action.
Impact of industrial activity on livelihoods of neighbouring communities of Nyenyeri and Kabarore villages.	Issues raised by both village residents are: • Loud Noise mostly from the crushers and ball mills. • Cement and coal blown dust deposits on house roofs and in houses, on	• With an anticipated high cost and National inconvenience of shifting Cimerwa Plc compared to relocating the neighbouring communities and the possibility of this affecting the construction material on a national level, it is proposed that communities surrounding the Industry are expropriated to create a health Industrial buffer zone. In this regard, since the only existing regulations on buffers are between 100 m up to 1,500 m around the SEZ from the 2019 Urban planning code and 500m from the industry chimney from 2017 Rwanda National land use planning	Immediate action.

Parameters	Non-conformities for the Industry	Corrective Actions proposed	Planned time for implementation of Actions
	leaves of trees for households close by. • Storm water discharged from CIMERWA, a potential source of flooding some homes of Nyenyeri village.	guidelines and no specific regulations are yet available from MINICOM, the Audit proposes expropriation of neighbouring communities in radius of 500m from the Industry's chimney as the industrial buffer zone to minimize the impact of the industry's dust emissions, noise and vibration on the residents. • In the proposed buffer zone, a green belt around the boundary of the new plant is proposed for establishment to suppress noise, dust effects and control stormwater. This should be a well-planned green belt with right kind of planting not to result in a source of malaria, a bush of rodents or haven of thieves.	
Industrial buffer from sensitive areas. e.g. residentials	Inadequate or rather no buffer zone between the industry and the residential communities. Some residents are within 8m from the Industry wall fence on the side of Nyenyeri village, while others are within the 200m radius from the Industry.		
Environment Health and safety (EHS)			
EMP or EMS or Environmental Policy Implementation	Inadequately addressed mitigation measures from the 2009 ESMP for the new factory were: • No planted green belt and earth mounds in the zone between new cement plant and township around the premises to minimize on	• The proposed new industrial zone from the new factory boundaries shall be planted as a green belt with trees and other plants to absorb fugitive dust from the factory and suppress noise to any neighbouring communities. As conceived by (Orkomi, et al., 2013), noise suppression by planting trees around the factory is a remedy observed in their research at the Tehran cement industry to ensure the noise level from a cement industry has been reduced to a tolerable level at the residential area. • According to (USDoL, 2013), installation of noise mufflers/silencers in the high noise emitters. i.e. the mills and crushers, could reduce noise emissions. Once installed, mufflers must be cleaned on a regular basis to	Immediate

Parameters	Non-conformities for the Industry	Corrective Actions proposed	Planned time for implementation of Actions
	fugitive dust emissions and suppress noise. • No extensive vibration monitoring system to check and reduce vibrations. • Inadequate storm water and runoff control systems on site to minimize the quantities of suspended material carried off site.	be effective at reducing noise, otherwise, they actually can increase noise levels. • Furthermore, applying vibration damping of the mills and crushers with material like mastic, asphalted felt, plastic foil or any other viscoelastic material will reduce vibration levels. • By establishing the new sedimentation settling tank for treatment of the stormwater cement effluent discharged by Cimerwa, issues arising from the stormwater would be controlled, such as; suspended solids, heavy metal polluters to the soils and ground/surface water, speed and volume of stormwater that was previously discharged and that contributed to floods affecting homes in Nyenyeri village.	
Air quality monitoring and control	Ambient air quality monitoring in and outside of the factory premises are not monitored.	• Continuous ambient air quality monitoring could be done to establish compliance towards tolerance limits of National and international standards. This can be done and results diligently submitted to REMA for review and record purposes. This will establish that workers and surrounding communities are not exposed to pollutants that could eventually cause health hazards.	Immediate action.
Noise monitoring and control	Non-compliance to national and international standards of noise/sounds levels specific to the areas of the raw mill, coal mill, cement mill and end of the kiln near the cooler, as observed by the 2019 RSB-Cimerwa occupational noise survey.	• Preferably noise mapping of the plant and noise level monitoring for the different factory departments and also the extent of its impact to the neighbourhood could be done to establish compliance towards tolerance limits of National and international standards. This can be done twice a year and results diligently submitted to REMA for review and record purposes. This will establish that either workers and the neighbourhood are not exposed to unacceptable noise levels that could eventually result in deafness.	Implement a noise monitoring survey twice a year.

Parameters	Non-conformities for the Industry	Corrective Actions proposed	Planned time for implementation of Actions
	Other than this survey, there were no records of noise levels monitored on premises and its noise impact on the neighbourhood.		

7. CONCLUSION AND RECOMMENDATIONS

7.1. Conclusions

Conclusions of the Environmental audit with regard to the status of conformity of the newer factory of Cimerwa Plc towards National policy and legal framework, National and international standards, its location relative to its areal zoning, as well as to environmental, health and safety performance indicate that Cimerwa conformed to standards of acceptable vibration levels, permissible limits of BOD, Cl-, SO_4^{2-}, NO_3^-, PO_2^{4-}, Oil and grease and Zn, most of the EHS requirements.
However, due to factors such as; its location surrounded by a residential area with a relatively high-density population, by virtue of the cement process with a process that emits dust, noise and vibration, Cimerwa did not conform in the following manner:

- Cimerwa cement factory is located in an area still zoned as residential, as many settlements develop in its proximity in the 35 years of its existence, resulting in the complaints by neighbouring communities of pollution by Cimerwa. To this effect, the District has not conducted a masterplan to change the type of zoning that will inform the acceptable land use type and hence the applicable standards of compliance. i.e. Industrial or residential.
- The higher PM_{10} and $PM_{2.5}$ dust levels of neighbouring sites to the factory compared to the baseline site show that neighbouring sites were subjected to higher dust levels than the baseline by virtue of proximity to Cimerwa.
- For areas along the road from the quarry, areas less than 150m from the road are the most dust polluted.
- Noise levels are above the residential and silence zone permissible standards for most sites outside the factory boundaries up to a radius of 500m from the factory, probably a result of noise from cement production processes, mostly ball mills, crushers and kiln and also the comparison of noise levels from an industry against residential noise standards.
- Stormwater sample and sediment from Cimerwa showed non-compliance to permissible limits of pH, conductivity, TDS, TSS, turbidity, COD, Pb, Cu, Cd.
- Cimerwa implemented most of the mitigation measures proposed in the 2009 ESMP for the new cement plant but was short on implementing some of the measures including; a green belt with earth mounds around its boundary to suppress noise and dust, storm water and runoff control systems on site to minimize the quantities of suspended material carried off site.
- Ambient air quality monitoring in and outside of the factory premises are not monitored and only stack emissions are monitored.
- Other than occupation noise survey conducted in 2019 by RSB, there were no records of noise levels monitored on premises and its noise impact on the neighbourhood.

These non-conformities in certain instances relate to some of the complaints raised by neighbouring communities, such as noise and dust and are mostly based on comparison to residential standards but most of them could be compliant if the area of Cimerwa's location was zoned Industrial and hence compliant to Industrial standards.
Recommendations have been made as part of an action plan with proposed measures that can be taken to avoid, eliminate or minimise the Industry's non-conformities. A planned time was also proposed against each of the measures as part of this Action plan.

7.2. Recommendations

Recommendations of actions to be taken towards rectifying non-conformities by Cimerwa have been elaborated in the corrective action plan under chapter 6. Most of the actions

presented are the full responsibility of Cimerwa Plc to implement, with a couple of exceptional responsibility shared with Rusizi District.
The recommended actions are presented herein:

- First of all, the issue of zoning of the area between Industrial and residential needs to be discussed and resolved by Rusizi District. This will rectify the compliance requirements of the factory from residential to only Industrial standard requirements and minimize the increment in settlements closer to the factory.
- Basing mainly on Cimerwa's non- compliance towards residential standards as per its current area zoning, it is recommended that a buffer zone be established between the factory and closest resident that is at least 500 m from the Industry chimney by relocating those within this 500m radius, based on the recommendation of 500m from the industry chimney from 2017 Rwanda National land use planning guidelines and also backed data from this audit that showed acceptable noise levels were obtained at 500 m from the factory.
    - This relocation may be approached by freezing new constructions first, and gradually resettling the existing residents starting by the most exposed to industrial dust and noise pollution of Nyenyeri community.
    - Options of areas proposed in case of relocation during the public consultation for consideration by Cimerwa were: Cimerwa owned land in Rubero village in shara cell and Mashesho cell.
    - In case relocation is pursued, it is recommended that the option of land for land is applied rather than cash for land to avoid squandering of cash by affected communities.
    - The buffer zone once in place can be planted as a green belt with trees and plants to suppress noise and dust from the neighbourhood.
- Install noise mufflers/silencers in the high noise emitters. i.e. the mills and crushers, could reduce noise emissions. Once installed, mufflers must be cleaned on a regular basis to be effective at reducing noise, otherwise, they actually can increase noise levels.
- Sedimentation settling tanks have been proposed as a wastewater treatment system for treating stormwater cement water effluent to levels permissible for discharge to the environment. Regular self-monitoring of effluent discharged by the treatment to the environment is also subsequently recommended at least quarterly.
- To minimize dust pollution along the Amashyuza quarry road, the following actions are proposed:
    - Continuous water spraying of the road to reduce dust raised.
    - To slow down trucks that raise dust, measures should be put in place by Cimerwa in collaboration with local authorities and police. Such measures comprise; enforcing lower speed limits and adjusting speed governors in trucks to that effect, speed limits along the road more enforced, humps placed along the road.
    - Consider paving the road with asphalt.
- Continuous ambient air quality monitoring could be done to establish compliance towards tolerance limits of National and international standards. This can be done and results diligently submitted to REMA for review and record purposes. This will establish that workers and surrounding communities are not exposed to pollutants that could eventually cause health hazards.
- Preferably noise mapping of the plant and noise level monitoring for the different factory departments and also the extent of its impact to the neighbourhood could be done to establish compliance towards tolerance limits of National and international standards. This can be done twice a year and results diligently submitted to REMA for

review and record purposes. This will establish that either workers and the neighbourhood are not exposed to unacceptable noise levels that could eventually result in deafness.

8. CIMERWA FEEDBACK AND COMMENTS ON CORRECTIVE ACTIONS PROPOSED BY THE ENVIRONMENTAL AUDITOR

As part of the Environmental Audit report, feedback and comments from CIMERWA on the audit's proposed corrective actions have been included as shown in the table below.

Table 27: CIMERWA feedback and comments on corrective actions proposed by the Environmental Audit.

AREAS OF FOCUS	Corrective Actions Proposed by EA experts	CIMERWA feedback and Comments
1. AMBIENT DUST ➢ **Mashyuza road**	➢ Continuous water spraying of the road to reduce dust raised. ➢ To slow down trucks that raise dust, measures should be put in place by Cimerwa in collaboration with local authorities and police. Such measures comprise, enforcing speed limit by inserting speed governors in trucks, speed limits along the road more enforced, humps placed along the road. ➢ Since the road to the quarry is a public road, the local authorities together with Cimerwa may embark on a tree planting in the accepted 12m class 2 road reserve of this public road to serve as suppress dust from the road traffic. Furthermore, local authorities will also endeavour to avoid settlements within the road reserve. ➢ Consider paving the road with asphalt.	- Continue & increase water spray on the road by assigning a specific contractor for the task. - The current speed limit for CIMERWA haulage trucks is 40Km/hr.This will be calibrated to 30Km/hr. - Speed Humps will be installed on the Road to Mashyuza at selected points. - The distance between the road and some community houses does not meet the road reserve requirements. We request for this to be looked at together with authorities responsible and appropriate action taken to reduce associated road safety risk to CIMERWA and the public.
➢ **Villages around the factory**	➢ First of all, the issue of zoning of the area between Industrial and residential needs to be discussed and resolved by Rusizi District. This will rectify the compliance requirements of the factory from residential to only Industrial standard requirements and minimize the increment in settlements closer to the factory.	The factory was built by the Government and no buffer zone considered at that point. The community has continued to expand closer to the factory over the last 35 years. Most of the community houses were built after the factory had been constructed.

AREAS OF FOCUS	Corrective Actions Proposed by EA experts	CIMERWA feedback and Comments
	➢ Recommended that a buffer zone be established between the factory and closest resident that is at least 500m radius from the main chimney, based on the recommendation of 500m from the industry chimney from 2017 Rwanda National land use planning guidelines and the distance of dust level exposure of neighbouring community compared to the study baseline site. This may be approached by freezing new constructions first, and gradually resettling the existing residents starting by the most exposed to industrial dust and noise pollution of Nyenyeri community. ➢ In case relocation is pursued, it is recommended that the option of land for land is applied rather than cash for land to avoid squandering of cash by affected communities. ➢ Continuous ambient air quality monitoring could be done to establish compliance towards tolerance limits of National and international standards. This can be done and results diligently submitted to REMA for review and record purposes.	CIMERWA requests that the Government should consider applying industrial and not residential standard requirements in the area around the factory. We also request that a buffer zone preventing further development around CIMERWA factory is created. Continuous Ambient Monitors (already purchased) to be installed around the factory zone to monitor the emission and noise levels to the community. **Discussion is necessary between CIMERWA, District authorities, authority in charge of Land use master plan, REMA, and other organs to align on (a) way forward regarding the issue of Masterplan of the area that puts the factory into a residential area and (b) how to solve the current settlement pattern at the factory, especially urgently preventing further building of houses close to the factory. Consideration should be given to the fact that the residential houses developed over the years after the factory was built.**
2. NOISE	➢ The Audit proposal to establish a 500m buffer zone from the chimney around the factory mentioned above, is again supported by the results of ambient noise variation with distance from the factory in figure 39 above, where acceptable noise levels were obtained at 500 m from the factory. ➢ The buffer zone once in place can be planted as a green belt with trees and plants to suppress noise.	- In general, as per the industrial standard requirement, CIMERWA meets the requirements. Nevertheless, Engineering solutions will continue to be implemented to reduce noise levels. - The key challenge is the closeness of the Community to the Factory site where Zoning was not considered, and

AREAS OF FOCUS	Corrective Actions Proposed by EA experts	CIMERWA feedback and Comments
	➢ Installation of noise mufflers/silencers in the high noise emitters could reduce noise emissions. i.e., the mills and crushers. Once installed, mufflers must be cleaned on a regular basis to be effective at reducing noise, otherwise, they can increase noise levels. ➢ Preferably, noise mapping of the plant and noise level monitoring for the different factory departments and the extent of its impact to the neighborhood could be done to establish compliance towards tolerance limits of National and international standards. This can be done twice a year and results diligently submitted to REMA for review and record purposes.	no control has been enforced over the years with respect to housing expansion towards the factory: **Discussion is necessary between CIMERWA, District authorities, authority in charge of Land use master plan, REMA, and other organs to align on (a) way forward regarding the issue of Masterplan of the area that puts the factory into a residential area and (b) how to solve the current settlement pattern at the factory, especially urgently preventing further building of houses close to the factory. Consideration should be given to the fact that the residential houses developed over the years after the factory was built.**
3. VIBRATION	➢ The two locations in Nyenyeri village with higher vibration levels than permissible standards give an indication of urgency of relocating homes in Nyenyeri village within the 500m distance from the factory chimney. ➢ CIMERWA could apply vibration damping of the mills & crushers with material like mastic, asphalted felt, plastic foil or any other viscoelastic material to reduce vibration levels.	- CIMERWA believes that the factory is built in a high seismic zone where always nature movement are happening. - We will continue monitoring Vibration levels using certified equipment. - The equipment and standard used to monitor the Vibration levels during audit needs to be verified. - Some of the complaints related to house cracks as raised by the community CIMERWA is attributed to materials used to construct the house than Vibration cause.
4. WATER AND SEDIMENT QUALITY:	➢ Sedimentation settling tanks, can be used as a treatment system for cement stormwater effluent from CIMERWA to levels permissible for discharge to the environment. With this system, alkaline pH levels could be corrected to	CIMERWA believes that the point of sampling is not representative as previous wastewater analysis report conducted by WASAC did not identify such metals.

AREAS OF FOCUS	Corrective Actions Proposed by EA experts	CIMERWA feedback and Comments
➢ pH of stormwater sample was at 11.76 above limit of pH 8.5. ➢ Conductivity ➢ TDS, Turbidity ➢ Heavy Metals	permissible levels by acidification, turbidity can be corrected by additional chemical coagulation with reagents such as such as aluminum sulphate and ferric chloride. By settling, heavy metals attached to the sediment at the bottom of the chambers can be removed along with the sediment. ➢ Also applying phytoextraction or phytoremediation technique of introducing plants to uptake heavy metals could contribute to the efficiency of the proposed sedimentation tank treatment system of cement effluent.	However, measures are underway to limit any pollutants to the community – we have commenced a study to identify where to install a settling structure before storm water is discharged. INES Ruhengeri University is engaged to do wastewater quality analysis. This is an annual exercise as per the legal requirements. However, going forward, the exercise will be done on a bi-annual basis.
5. PUBLIC SOCIAL RESPONSIBILITY ➢ Impact of industrial activity on livelihoods of neighbouring communities of Nyenyeri and Kabarore villages.	➢ Rusizi District to consider preparing a master plan for this area by zoning to avoid conflicts between resident communities and CIMERWA Plc over eligible land use of this area between residential and industrial. ➢ Since the only existing regulations on buffers are between 100 m up to 1,500 m around the SEZ from the 2019 Urban planning code and 500m from the industry chimney from 2017 Rwanda National land use planning guidelines and no specific regulations are yet available from MINICOM, the Audit proposes expropriation of neighboring communities in radius of 500m from the Industry's main chimney as the industrial buffer zone to minimize the impact of the industry's dust emissions and noise on the residents. ➢ In the proposed buffer zone, a green belt around the boundary of the new plant is proposed for establishment to suppress noise, dust effects and control stormwater.	CIMERWA believes that it does its best to meet emission legal requirement standards. However, the current Masterplan of the areas that puts the factory into a residential area needs to be discussed with responsible authorities for proper guidance. Lastly, CIMERWA believes that if coordinate points of sample collection is considered would make report more scientific. **Discussion is necessary between CIMERWA, District authorities, authority in charge of Land use master plan, REMA, and other organs to in order to align on (a) way forward regarding the issue of Masterplan of the area that puts the factory into a residential area and (b) how**

AREAS OF FOCUS	Corrective Actions Proposed by EA experts	CIMERWA feedback and Comments
6. ENVIRONMENT HEALTH AND SAFETY (EHS)	➢ The proposed new industrial zone from the new factory boundaries shall be planted as a green belt with trees and other plants to absorb fugitive dust from the factory and suppress noise	**to solve the current settlement pattern at the factory, especially urgently preventing further building of houses close to the factory. Consideration should be given to the fact that the residential houses developed over the years after the factory was built.**

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Annex 1- Photolog of field observations and public consultation


Public consultation


Dust deposit on roofs& dishes


Dust deposited on tree leaves and roofs.


Proximity of factory to Nvenveri residences


Water spraying at Factory entrance.


Stormwater Discharge channel & collapsed wall


Proximity of factory to Nyenyeri residences


Cracks on house in Nyenyeri claimed to be a vibration effect.


Speed limits to reduce on accidents and raising dust by trucks on the Amashyuza quarry road.


Dust from a Cimerwa truck with limestone from the quarry.


Cracks on house in Kabarore claimed to be a vibration effect.


Cracks in house in Nyenyeri claimed to be a vibration effect.

Annex 2- List of those consulted.

Name	Institution	Position	Telephone	Email
Francis Kayumba	Cimerwa	SHERQ	0782029993	Francis.Kayumba@cimerwa.rw
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Meshack Ndaba	Cimerwa	Process Engineer/ Cimerwa	0788970504	-
Mutagaramba J D	Cimerwa	Human Resource officer	0788534388	-
Kayumba Ephrem	Rusizi District	Mayor	0788479930	-
Raguha Laurien	Rusizi	Construction Permit Engineer/ One stop centre	0783731880	-
Ngirabwatare James	Muganza Sector	Executive secretary	0788222828	-
Habumugisha Jacques	Nyenyeri	Local resident	0783549825	-
Tegibanze Zephanie	Nyenyeri	Local resident	0780817677	-
Hitimana Jeremie	Nyenyeri	Local resident	0780083895	-
Mukanyangezi Chantal	Muganza sector	Land manager	0783016805	-
Majyambere	Kabarore	Local resident	0726329929	-
Sibomana	Kabarore	Local resident	0722056899	-
Naramabaje Modeste	Nyenyeri	Local resident	0783640187	-
Nkurunziza Vedaste	Kabarore	Village leader / Mudugudu	0725678938	-
Hazimana Anthere	Nyenyeri	Local resident	0788821792	-
Ntawukimara Samson	Shara cell	Executive	0783529028	-

Annex 3- Auditors and their qualification

NAME	POSITION	QUALIFICATION	Experience
Songa Silvin	Team Leader	MSc. Environmental Science and Technology, Bsc. Civil Engineering.	18 years of professional experience in environmental, civil works, construction related fields and public procurement, 13 years specific experience in the environmental sector.
Jimmy Gasore	Air quality expert	PhD in Atmospheric sciences Bsc Physics	10 years' experience in the sector of Atmospheric sciences, air pollution management
Mardochee Birori	Water quality expert	MSc. in Environmental science, specialization on water quality management.	22 years of professional experience specific to water quality.