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ENVIRONMENTAL IMPACTS OF QUARRY STONE MINING IN IGEMBE SOUTH SUB COUNTY, MERU COUNTY

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ABSTRACT*: There has been concern about the environmental impacts of quarry stone mining on affected areas. The objective of this study was to evaluate the relationship between quarry stone mining and environmental impacts in Igembe South Sub County, Meru County.Data was collected using from participants' notes to detect mining-related problems, and an informal and formal survey and pair-wise assessment was used. At a 0.05 level of significance, the hypotheses were evaluated. Ho1: Quarry stone mining has no significant environmental impact on the communities in Igembe South Sub-County, Meru County. Information was obtained from 300 respondents through surveys and interviews. Data were analysed using the nearest neighbour analysis method and descriptive means, median, and mode statistics. Further Chi-Square tests were used to generate inferential statistics. Results established that mining activities have damaged land in Igembe South Sub-County, reducing food production and agricultural demands and polluting water supplies in the area, including contaminated streams. Pollution and noise are present in the area. It was affirmed that the residents know the environmental consequences of mining. The research demonstrates that mining has an impact on the environment, as well as community social and economic well-being. In light of the County Government of Meru's efforts at restoration and intervention, such as re-afforestation, the mining companies and the County Government of Meru are reviewing their methods of operation and providing alternatives to the affected areas. Mining's environmental impact should be reduced by rethinking the environmental management strategy.*

Key Words: *Environmental, Impact, Quarry Stone, Mining, Meru County.*

I. INTRODUCTION

Recently, mining countries have drawn their attention to sustainable mining practices (Chen *et al*., 2022). Sustainable mining practices emphasize on mining that has minimal negative social-environmental impacts. For instance, Mourinha, (2022) notes that in America, Asia and Europe mining sectors emphasis has been drawn towards minimizing surface water impacts; minimizing groundwater impacts; use of environmental indicators in mining; and emerging mining technologies that minimize environmental impacts. Many countries in Europe and in India have passed various government regulations on sustainable mining practices addressing areas such as volume of waste generated during mining, mine closure planning, managing the environmental impacts of mining, land use planning, and energy use management (Kimijima, 2022).

Igembe South, Sub-County, Meru County is located on the windward slope of Mt. Kenya. Rain-fed agriculture is essential to the people's survival. Individuals without work are increasingly turning to alternative methods of income, such as sand and quarry stone mining, because their cash crops, such as khat, are not being purchased in significant amounts, and their revenue from tea and coffee is low (Wanjiku,2015). The construction sector relies heavily on sand and quarry stones. Because of the growth of cities, sand and quarry stones are becoming increasingly attractive. Quarry stone extraction has long been done along the Maua-Kangeta-Meru road. Mining for quarry stone has benefited Maua, Kangeta, and Karama. Mining operations, notably sand mining, in Meru National Park have led in the creation of similar communities (Makhura, 2021). Sand and quarry stone mining have risen rapidly as a result of the establishment of the County Government and the rapid expansion of towns. This mining, if not done correctly may have adverse consequences on the land. Human actions such as extracting natural resources and displacing workers, as described by MacFortone (2016) and Mitchell (2016), alter the nature of the terrain. Extraction of sand and quarry stones destroys underground aquifers, affecting the quality and quantity of surface water accessible for human and animal use and the aquatic ecology, not to mention riparian vegetation. Environmental damage from faster soil erosion on nearby areas and roadways, social and health issues such as high school dropout and prostitution, and the spread of venereal diseases are among the consequences. Local employment is one of the social and economic benefits.

According to Mbathi *et al*.,(2019), the temporary community gains proportion is relatively low. Previous studies done have not adequately investigated the environmental impact of quarry stone mining. They have methodological, conceptual and contextual limitations. For instance Kibii (2020) studied social effects of stone quarrying in Tuluongoi Sub Location Baringo County. The study by Kibii (2020) failed to investigate the spatial distribution of mining sites. Was based in a different county and analyzed data using frequencies and percentages which did not allow to test the hypothesized relationships between the variables. A study by Nyakeniga (2021) assessed the environmental impacts of stone quarrying activities in Nyambera Location Kisii County. The study was contextualized in a different locality. The study was contextualized in a different county and failed to chart out the spatial distribution of mining sites. As a result, environmental repercussions on the people of Igembe South Sub County, Meru County, were investigated in this research. The government of Kenya has recently promulgated various regulations, such as the Mining Act (2016) and the Mining Guidelines of (2020), meant to curb the adverse effects of Mining in Kenya. Regardless of these regulations, recent studies have yet to assess environment impact of quarry mining. Therefore the spatial distribution and impact of quarry stone mining in Kenya since the promulgation of the regulations remains to be discovered. Extant studies have been faulted on several aspects; First, Okla's (2017) & Assumma *et al*. (2022) studies were contextualized in other countries and hence have a minimal application to Kenya. Second, the studies by Simpson Jr & Dussubieux (2018) had methodological limitations since they predominantly used descriptive statistics and critical literature reviews, which did not allow testing of hypothesized relationships. Further, Blachowski & Buczyńska (2020) did not focus on the social, economic, and environmental effects of mining.

Human activities that are not sustainable almost always have a detrimental impact on the surrounding environment and socioeconomic aspects. The environmental impacts are long-lasting, and most of the time, they are irreversible; if they can be reversed, it may take a very long period. Communities in regions where land mining has been going on for an extended period are being negatively impacted by methods that are not sustainable. This is because once the borders of the environment are crossed, making amends for one's actions is impossible.The study was conducted to determine the environmental implications that mining operations have on the populations in the area. Despite recent government regulations aimed at curbing the negative impact of mining, extant studies report glaring inefficiencies in mining that could impact human activities. Extant recent studies have yet to establish the impact of quarry stone mining on the environment and social and economic activities.

The objective of the study was to valuate the relationship between quarry stone mining and environmental impacts in Igembe South Sub County, Meru County. The hypotheses was been evaluated at the 0.05 level of significance in this study: Ho_1 - Quarry stone mining has no significant environmental impact on the communities in Igembe South Sub-County, Meru County

The research findings from this study will enlighten the counties and the national government on developing mechanisms that attempt to reduce the impact of quarry stone mining on the environment and social and economic human activities. The study will also be necessary to the Ministry of Mining, Blue Economy, and Maritime Affairs, who are policymakers in understanding the role played by quarry stone mining on the environment and social and economic human activities so that they can put them into practice in their effort to enhance the sustainability of mining in Kenya.

II. LITERATURE REVIEW

Land mining site activities have a well-documented negative environmental impact on the ecosystem World Health Organization (2019). The environmental consequences of large-scale and small-scale mining have garnered considerable attention. While mining has a negative influence on the environment, chemical contamination from the extraction process has a twofold impact, endangering the health of mining communities and those who live nearby. Several studies in mining communities, according to Yelpaala (2015), have highlighted environmental concerns such as soil deterioration, water pollution, and air pollution. In Tarkwa, Ghana, significant tracts of land have been cleared away of vegetation to make space for surface mining operations, according to Akabzaa and Darimani (2021). More than 70 percent of Tarkwa's territory is currently occupied by open-pit mining concessions. There are heap leach facilities, tailing dump and open pit mine camps, roadways, and the relocation of displaced people believed to have taken up the whole concession space of a mining corporation by the end of mining operations. This substantially negatively influences the population's primary income sources, which are land and vegetation.

Due to the high concentration of mining activities in the area, the environment in most fields is deteriorating, and the area's substantial economic output is decreasing year after year. In agricultural districts, the duration of follow-up has decreased from 10-15 years to 2-5 years due to the loss of arable land. Due to land constraints, the traditional bush follows a system that successfully recycled significant amounts of nutrients while producing the following cycle, which is no longer practicable. According to Akabzaa and Dorimani (2021), large-scale mining operations have a history of diminishing the flora in the area to levels that are hazardous to biological diversity.
Surface mining's deforestation has long-term consequences; even after a mine is decommissioned, the soil is restored, and trees are replaced. The introduction of new species can change topsoil composition, affecting soil fertility and the length of time that crops remain fallow. The land's agricultural viability deteriorates as surface vegetation disappears and birds and other species lose habitat and erosion. As a result, lush plant life, biodiversity, cultural places, and water bodies have been lost. A word that can describe a person is akabzaa (2021). The ridges of 120 to 340 meters high that people and corporations leave behind in their mining concessions will transform into giant valleys, according to Darimani (2021). Therefore the effect of mining on degradation of land has not been systematically explored by extant studies.
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Mines attempt to reduce the water table or redirect major streams away from their operations. A study by Liu *et al*. (2021) posited that water pollution is greatly enhanced by human activities such as mining; the study was a critical literature review and needed to collect original data like the approach of the current study. A study by Omare *et al*.,(2021) noted a high concentration of mining operations in Igembe South. Further the study observed that pollution of surface and groundwater had worsened. However the study did not attempt to link mining and water pollution as a cause and effect. There are four significant water contamination problems in mining areas. Chemicals can pollute streams and groundwater, and siltation can occur due to increased sediment load. Extant study by Chauhan (2010) observed that large scale mining and mining support companies emit a significant amount of air pollutants. The study pointed that the residents in affected areas are concerned about air pollution, including airborne pollutants, black smoke emission, noise, and vibration. Dust, carbon monoxide, sulfate and black smoke are some airborne pollutants that miners should be aware of to protect themselves and their families. Site preparation and road building, open-pit drilling and blasting, vehicle traffic, ore and waste rock handling, and heap leach crushing by firms during heap leach processing are all sources of particle pollution. Sulphide ore roasting and refining produces toxic vapours. This study however was a critical literature review and did not test the relationship between mining and air and noise pollution, the current study was an attempt to fill this knowledge gap using original data from mining cites in Igembe central.

Residents of mining areas face a health risk due to the emission of airborne particulate matter, primarily microscopic dust particles smaller than 10 microns, into the environment. As well as causing respiratory problems, fine dust can aggravate arthritic symptoms in some people. The high concentration of silica in mining dust has been related to the development of silicosis in the area. Because mining companies have not taken the essential steps to prevent harmful dust emissions into the atmosphere, people are in danger of breathing difficulties. Regularly spraying roads within mining leases is the only way to reduce dust emissions. Road dust does not appear to be the primary source of air pollution; thus, this wastes time. The EPA is also aware that dust suppression on roadways and prayer frequency, particularly at mining sites, are insufficient. A country's overall waste output can be considerably impacted by mining's intrinsic nature, which produces large volumes of waste. Metal and coal mining are significant contributors to material flow inputs in the United States; for example, Mathews (2016). The amount of waste a mine generates is determined by the minerals taken and the mine's overall size. Quarry stone, gold, and silver are among the most wasteful metals, with nearly all ore mined. About 60% of the ore mined from the ore is treated as waste, according to Da Rose (2019).

Massive amounts of waste, which could have a substantial environmental impact, are an issue for the mining industry. Despite producing less waste, open-pit miners face harsher fines than their underground counterparts. The destruction of aquatic ecosystems and receiving water bodies, which frequently results in a significant decline in water quality, is one of the most catastrophic repercussions of metal extraction. Two of the primary sources of water contamination are sedimentary acid discharges and metal deposition, Sampart (2019). Across many mines, the environmental impact of disturbed organic materials in nearby streams and other aquatic ecosystems is a primary issue. The sediment load of nearby water bodies is often increased by erosion from waste rock piles or runoff following severe rainfall. Mines can alter the geomorphology of a stream by obstructing or diverting its flow, altering the slope or stability of the stream channel, and more. According to Johnson (2017), these disruptions could significantly impact the stream sediments' characteristics, resulting in a drop in water quality. In addition, an increase in silt load can suffocate benthic creatures in streams and oceans, removing vital food sources for predators and reducing the amount of habitat available for fish to pass through and spawn Johnson (2017). When there is a lot of sediment in a stream, the depth of the water can go shallower, which increases the likelihood of flooding during periods when the stream flow is high, Mason (2017).

Acid drainage is one of the most severe detrimental consequences that mining may have on the surrounding ecosystem. Sulfuric acid is produced whenever sulfide-containing minerals, such as pyrite or pyrrhotite, are exposed to oxygen or water. This phenomenon can take place. It is common for the process to become more widespread when acid-consuming bacteria are present. The subsequent leaching of different metals from the rocks by acidic water can lead to the contamination of both the surface water and the groundwater. In mining, acidic effluents are typically produced from waste rock heaps, exposed waste mine shafts, and pit walls. This process could take a short amount of time, but it will keep on going until no more sulfides are left. Given the vast amounts of rock exposed at specific mining sites, this process can take millennia to complete. Even though the process is chemically complicated and poorly understood, specific situations can lessen the possibility that it will take place. Acid drainage is less likely to occur if neutralizing minerals (such as carbonates) are accessible, the PH environment is basic, or preventive measures are taken. This remains true regardless of whether the surrounding environment is acidic or not, Schmiermund and Drozd (2017).

Acidic water is discharged into nearby streams, and surface waterways harm aquatic life. A significant number of fish are extremely sensitive to even slightly acidic water and are unable to reproduce in environments with pH levels lower than 5. Predicting the possibility of acid drainage can assist in locating possible trouble spots in the background. The methods range from straightforward calculations, including weighing the presence of acid-generating minerals against those of neutralizing minerals (such as calcium carbonate), to in-depth laboratory examinations (i.e. kinetic testing). Metals, reagents, and other chemicals are used in most mining processes to process precious materials. Chemicals such as heavy metals with conductive qualities, such as cyanide and mercury, are widely used. Acid drainage or unintentional leaks from mine tailings impoundments can also discharge metals into the environment. Many species require heavy metals for survival, but excessive amounts can be detrimental. Even while only a few species of land animals and aquatic organisms are born immune to heavy metal poisoning, some have evolved a resistance to heavy metals over time. Plant and animal species reduce as heavy metal concentrations in water rise. According to Kelly (2018), some species are more vulnerable to heavy metals, such as salmon, which are more sensitive to elevated copper concentrations. Heavy metals can also alter a fish's reproduction and growth processes, making juvenile fish more vulnerable to them than adult fish. Mining may have extra indirect effects that are caused by the mining location. According to Fearnside (2019), the Carajas project in the Brazilian Amazon destroy 72,000 hectares of forest per year over the project's two-hundred-and-fifty-year lifespan to supply charcoal for pig-iron smelters. Specific ecosystems' vulnerability to mining is explored. The greatest threat to biodiversity posed by miners is the depletion of natural vegetation which provides food and shelter for animals. Mining has the potential to have a far greater impact on biodiversity than previously thought. Acidic river discharge and high metal levels in water are two examples of environmental threats. Some algae and crustaceans have been shown to thrive in environments with higher metal and acid concentrations. Weedy plants and insect pests may thrive, while valuable species (such as trees and animals) may become extinct. Mac Callum (2017) claims that bighorn sheep chances of survival are limited as a result of coal mines altering their natural habitat.

The majority of these studies concentrate on the mine's specific challenges, such as the fact that it relies on a sizable migrant workforce from both within and outside of South Africa. Several miners made significant efforts to establish HIV/AIDS prevention programs during the HIV/AIDS crisis, but it appears that these programs had little impact. Preventive efforts have largely ignored workers' psychological environments, particularly for migrants from neighboring countries who spend extended periods of time away from close family and friends. In Latin America, studies on mining-related community health programs are rare; however, Mac Callum (2017) investigated the costs and benefits of implementing child survival services at a private Peruvian mine. Studies by Awudi (2019) and advocated for greater transparency in the mining sector, particularly in Latin American, Asian, and African countries. A long-term study of the health effects of mining on mine workers and surrounding populations is also required. Long-term health effects for miners and the communities in which they live have been documented. If this is correct, industry operations endanger human development goals such as maintaining health for current and future generations, correct? Mining has a long way to go before it can be considered a good source of employment or an activity for community development. Furthermore, there is still a long way to go before industry, labour, and communities can provide explicit statistics on the sector's true health impacts.

III. METHODOLOGY

The location of the study was Igembe South which is between latitude 0.2664^{0}N to 0.379534^{0}S and longitude 37.953^{0}E to 38.001^{0}E. Correlative design was used to analyze the environmental impacts of mining on communities. The population of the study was Igembe South sub-county in Meru County residents which has a population of 145,301 people and occupies an area of 270.7 kilometers squared, according to the Kenya National Census by the Kenya National Bureau of Statistics (2019). In this study, simple random stratified and purposive sampling approaches were used. Following a rigorous selection of study communities based on their proximity to mining operations. From the population a sample of 300 people who were engaged in mining activities were randomly selected to complete a lengthy questionnaire via interviews, assuring a 100% completion rate.

Officers from the Environmental Protection Agency (EPA), the Ministry of Lands, Forestry, and Mines, as well as other NGOs working in the area, were interviewed. Officials and employees at nearby health centres were contacted for more information. Field observation programs were also set up to examine the environmental impacts of mining operations at mine sites and other locations. Secondary data was acquired from books, relevant articles, journals, research studies on the influence of mining operations on the internet, and other local sources. Data analysis includes the nearest neighbour method of analysis description of means, median and mode. The information was used to construct tables, graphs, and pie charts. Where applicable, other relevant mathematical and statistical methodologies, such as Chi-Square, were used in the investigation. The results of the analysis were presented in both qualitative and quantitative terms. Each complementing the other

IV. RESULTS AND DISCUSSION

Environmental Impacts of Quarry Stone Mining

Table 1: Negative Effects of Quarry Stone Mining

Impact	Frequency	Percentage
Degradation of Land and Vegetation	50	17
Water Pollution	127	44
Air Pollution	82	28
Noise Pollution	33	11
Total	292	100

From the table 6 above, the greatest adverse effect of quarry stone mining in Igembe south sub county was water pollution (44%). The example given is alluvial sand mining on dry river beds. Sand mining lowers the alluvial water table, posing a danger to water security (Pereira, 2012). Contamination from transport vehicles or even excavating machineries has an impact on water quality in the study region. These findings corroborate those of Stebbins (2016), who stated that oil spills and leaks from excavation machines and transportation trucks can contaminate water quality and poison aquatic life. In terms of open and subsurface water resources, the construction of ponds when harvesters dig on places with deep sand beds to create water ponds pollutes aquifers (Bagchi,2021). Similarly, stagnant water on quarry extraction sites creates an ideal hatching environment for mosquitos (Plate.3).

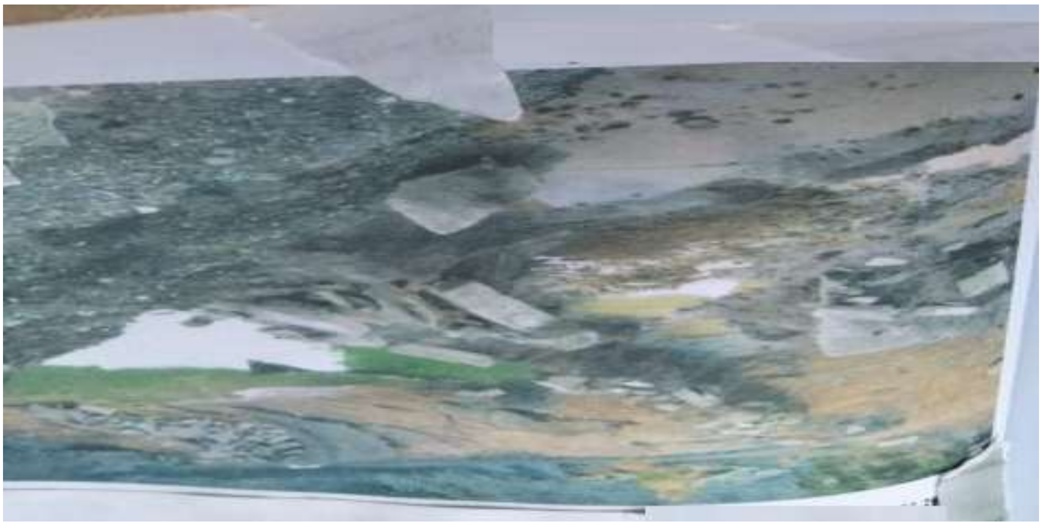

Plate 1: Stagnant Water on Quarry Pond a Conducive Ground for Mosquito Breeding

Air pollution (28%) and noise pollution (11%) were shown to have detrimental environmental consequences. This took the shape of big vehicles compacting the ground, which made a lot of noise. According to Lawal (2021), dust accumulates in dwellings, farms, and fields next to mining operations, causing noise and air pollution. Dust from the trails and quarrying activity contaminates clothes on the line and even enters homes. Air pollution from dust particles can be harmful to one's health, particularly respiratory illnesses. Because earth vibrations cause tremors, rock blasting produces noise pollution. Noise from excavation works might occasionally disrupt sleep and school hours. Overburden excavation and transporting cause uncomfortable vibration noise. Another notable effect of quarry excavation was degradation of land and vegetation in the area (17%). Gravel excavation and alluvial sand mining leave open pits which are associated with accidents of falls and drowning. In most instances mining operations cause deforestation and loss of biodiversity habitats. The case of mining in coastal areas is associated with salinasiation as sea water intrudes into the mine sites. A study carried by Ekosse (2019) on Kgwakgwe Manganese mine in Botswana revealed that demineralization and pollution of soils and surrounding areas were major environmental Impacts of mining.The findings showed soil contamination and stunted growth in plants. Still, loss of fertile land and habitat alterations are other impacts which disrupt and destroy ecosystems. Continuous mining removes all vegetation and destroys the top and subsurface, resulting in a decrease in the quantity of Fauna and Flora (Aromolaran, 2017). Destruction of plant and scenery also detracts from the natural beauty of the place, making it an eyesore. Quarrying alters the geomorphology and, in some cases, the land use, as well as the visual landscape. Children and grazing animals are frequently injured in quarry regions as a result of gaping holes left on bare ground as miners shift old mines to new ones.

Mining is linked to a variety of environmental consequences that occur as a result of mining operations. Some of the health problems are caused by mining activity. The majority of respondents from the various places in the sample population were quick to point out that the diseases that plagued their communities were linked to the region's mining industry. Respondents were asked what they thought about the health implications of mining. The years of education of the respondents, as well as their views on the influence of mining on health, were tallied (Table 7).

Table 2: Respondent's Views on Relationship between Mining and Health by Education

Years of Schooling (Education)	Are Diseases Related to Mining			
	Yes	No	No Idea	Total
none	28	8	4	40
Less than 4 years	5	0	0	5
4-6 years	18	13	4	35
7 – 9 years	86	22	4	112
10 – 12 years	78	5	1	84
13 – 15 years	20	1	1	22
16 – 18 years	2	0	0	2
Total	237	49	14	300

Chi – square (pearson) SPSS

Formula $x^2 = \frac{(0 - E)^2}{E}$

Where 0 is the observed frequency and E is the expected frequency

$$\text{Procedure} \quad \frac{(28-31.6)^2}{31.6} + \frac{(5-3.95)^2}{3.95} + \frac{(18-27.65)^2}{27.65} \ldots\ldots\ldots\ldots\ldots\ldots \frac{(0-0.0933)^2}{0.0933}$$

=34.25 DF 12 significance 0.001, 2_{12} (calculated) = 34.25, 2_{12} (tabulated) = 21.03 at (0.05 level of significance) Decision rule= present Ho if ^{2}(calculated) , >^{2}(tabulated), Since the calculated chi-square value is greater than the tabulated value the Ho is rejected and alternate Ha accepted.. Therefore, Chi-square value calculated 34.25 (12 df) , Tabulated value 21.03 (12 df), Probability (significance / value 0.001

Only 16.3 percent of respondents disagreed, with 79 percent claiming that mining activities was to blame for the diseases that plagued their town. The remaining 4.7 percent, on the other hand, had no idea what was going on. According to the chi square analysis, respondents' years of schooling, (education) influenced their perceptions on the link between endemic diseases in the area and mining activities. The bulk of the 192 respondents had "none" or only a few years of schooling (0–9 years), accounting for 64 percent of the total. 71.4 percent indicated that mining activities have resulted in the spread of endemic diseases in the region. Mining activities were to blame for the widespread diseases in the area, according to those with more years of schooling (10–18 years), who made up the minority of respondents, with 108 (or 36 percent) of both respondents attesting to this fact. As a result, respondents' assessments of mining's health effects were found to be positively related to their educational level (or years of schooling).

Effect of Food Production

Domestic food production in Igembe South is insufficient to meet the demands of the entire region. According to respondents, this is due to mining activities, since some farmlands have been set aside for mining or cash crop growing such as tea, miraa, (Khat) and coffee. Land degradation has come from the removal of top soils, trees, and plants for quarry stone deposits using heavy machinery. The land's nutrient level has been depleted, rendering it unsuited for agricultural usage. As a result, there are few farmland options accessible. Even among the available lands, mining operations have poisoned parts of them with poisons.

Mining activities have resulted in cyanide and arsenic concentrations in agricultural land, according to a spokesman from the Ministry of Food and Agricultural Directorate in Igembe South sub-county. Because they are ineffectual, they are no longer used for such purposes.

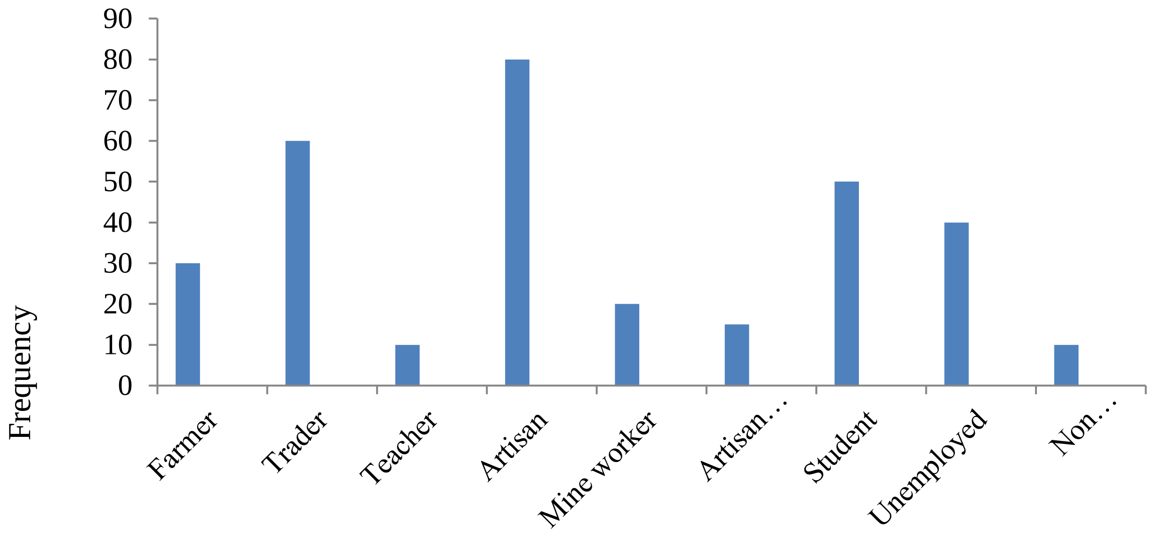

Figure 6. A simple bar graph depicting the respondents' occupational dispersion.

Source: Author's Sample Survey

Farmers accounted for only 25 of the 300 total responses, or 8.3% of the total. The majority of the respondents were traders, artisans, mineworkers (including artisan mine workers), and the jobless. This offers a vivid picture of how mining operations in the Igembe South area have damaged household food production. In Igembe South Sub-County, the effects of mining on the environment, water resources, and food production are particularly obvious and prominent, with negative health consequences. As a result, there is still more work to be done in order to improve the situation. The environmental implications of both surface and underground mining in their locations were well-understood by respondents. Surface and underground mining have varying degrees of impact, according to respondents. Roughly 94 percent of respondents said that mining operations in their communities are linked to environmental issues including land degradation and pollution, while only about 6% said that mining activities had no impact on their environment.

According to those surveyed in the five villages, land degradation is a severe consequence of surface mining. Depleting nutrients and making a region unsuitable for cultivation are just two of the many negative effects of heavy machinery. In Tiira, for example, the land has been overtaken by boulders and other detritus left over from mining operations. This has restricted plant development on the area, as well as making the surface harsh, making agriculture impractical. Furthermore, respondents claimed that as a result of these actions, pits and large holes/trenches are developed, and that these locations eventually become inaccessible to humans as fatal zones. Field inspections supported this, with holes ranging in depth from 20 to 30 meters deep discovered at the Amwamba and Auki mining sites. Even when the company backfills the pits, it either covers them with rocks, rendering the region unusable, or converts them into tailing dams, which store trash and other hazardous chemicals. Near settlements such as Murua in Kanuni ward and others, tailing dams were seen. Death trap pits and hard surfaces were also discovered near the company's facilities (plates 2 and 3).

Additionally, a higher proportion of those polled stated that surface mining was contaminated in some way, citing the use of hazardous goods, heavy machinery that could explode, and the existence of tailing dams as possible causes. In the real world, these findings were corroborated. In the study, surface and subsurface water pollution have been linked to mining activities, particularly surface mining. Increasing faecal matter, chemical pollution of ground water, and sedimentation of water bodies are the three main causes of water pollution. Residents of Maua town are at risk of developing waterborne infections because they consume water from the Mboone River. Surface mining activities are also linked to air pollution. Respondents' concerns were reflected in their fear of airborne particulate emissions on a regular basis. Chemicals with a foul odor and black smoke have been found in the impacted communities. They also complained about dust particles being thrown into the air during vegetation removal and blasting, as well as when large vehicles loaded and hauled other supplies. They are concerned that not only do these reduce visibility, but that they can also promote cardiovascular illness in residents. This issue was expressed by respondents, particularly those from the Auki mining site, which is close to open pits (0-1.5 km away) and (1.5-3 km away), both of which utilize a lot of chemicals in quarry stone treatment. Observations on the ground confirmed their suspicions. The pollution became increasingly annoying as the community got closer to the mining site.

Noise pollution is also prevalent in communities near mining regions and adjoining communities in the Igembe South sub-county; there is no way to avoid this environmental issue. Noise and vibration are caused by mobile equipment, air blasts, and vibration from blasting and other equipment. The majority of Maua respondents said that the noise and vibration not only cracked their roofs, but also generated fear and shock in their communities on a regular basis. Underground mining is also associated with noise and vibration, as the heavy machinery utilized creates ground shaking that may be felt on the surface. When quarry stone is crushed into little bits, this problem arises. Respondents, particularly those living near mining operations, expressed their dissatisfaction with the situation. Houses also had large fractures (ranging from 5-8cm wide), which respondents attributed to mine vibration. At several stages of the quarry stone mining operation, toxic gasses are used. Others include sulphide, carbon, and arsenic trioxide. If larger amounts are released into the air, they are very poisonous and detrimental to human health. There are times when air pollution is high, and the conservation of these compounds in the air is low, leading in gas fuses and other problems. In addition, both workers and residents in the neighboring areas have been exposed to toxins such as cyanide, hazardous compounds, and others. Toxic wastes created during such processes, on the other hand, are discharged into tailing dams, which pollute the land and air in the surrounding towns. The tailing dam prevented harmful chemicals from spilling into Igembe South's downstream settlements. Mining, by its very nature, produces large amounts of trash, which can contribute significantly to a country's total waste output. Fossils, fuels, and coal metal mining, for example, account for a large portion of material flow inputs and outputs (Mathew *et al*, 2019). The type of resources mined and the size of the mine determine the amount of waste produced. Quarry stone mining is one of the most inefficient industries, wasting more than 40% of the minerals collected. Iron mining, on the other hand, is less wasteful, with roughly 60% of the ore extracted being processed as waste (Da Rosa, 2019).

The mining industry faces enormous difficulties in removing this waste, which has a negative impact on the environment. Underground mines, which produce less water, are more affected than open pit mines. The degradation of quartic ecosystems and receiving water bodies, which often results in significant decreases in water quality, is one of the most catastrophic conceivable consequences of quarry stone extraction. The following factors contribute to water pollution: - Sedimentary acid drainage and quarry stone deposition (Sampat, 2019). At many quarry stone mines, minimizing disturbed biological waste that ends up in nearby streams or other aquatic ecosystems is a top priority. The sediment load of nearby water bodies is typically increased by erosion from waste rock heaps or runoff after severe storms. The morphology of streams has also been altered by mining, which has disrupted channels, diverted stream flows, and altered the slope or bank stability of stream channels. As a result of these disturbances, the characteristics of stream sediments are significantly altered, decreasing water quality, (Johnson, 2017).

The turbidity of natural water rose as sediment concentrations increased, lowering the amount of light available to aquatic plants for photosynthesis (Ripley, 2019). In addition, higher silt loads in streams and oceans can suffocate benthic animals, depriving predators of essential food supplies and reducing ideal habitat for fish migration and reproduction (Johnson, 2017). Increased sediment loads can reduce stream depth, putting floods at danger during high-flow seasons (Mason, 2017). One of the most serious environmental consequences of quarry stone extraction is acid drainage. Sulfuric acid is generated when sulfide-bearing minerals like pyrite or pyrrholites are exposed to oxygen or water. The process is often accelerated when acid-eating bacteria are present. Surface and ground water have been damaged as a result of the acidic water reaching other components in the rock. Water rock heaps, other exposed waste mine holes, and pit walls are all common places to find acidic effluents from mine operations. The process is quick and continues until no more sulfides are present. Given the vast amounts of exposed rock at certain mining sites, this could take decades. Even though the process is chemically complex and little understood, some circumstances can make it less likely. Acid drainage is less common if neutralizing minerals are available, the PH environment is basic, and preventative steps are implemented Schmiermund and Drozd (2017).

Acidic water that is thrown into nearby streams and surface waterways has an impact on aquatic life. Several fish species are particularly sensitive to even mildly acidic environments, and they are unable to reproduce when the pH falls below 5. If the PH level is less than 6, some are dormant (Ripley, 2019). Predicting the likelihood of acid drainage can aid in the detection of possible issues. Simple calculations and thorough laboratory testing are used, as well as simple calculations based on the balance of acid-generating minerals vs. the presence of neutralizing minerals. Even laboratory testing, however, was unable to predict the amount of quarry stone that had been leached if acid drainage occurred as a result of changes in scale and composition that happened during sample analysis (Da Rosa, 2017). To process precious minerals, most mining operations utilize metal reagents or other chemicals. Chemicals or heavy metals with conductive qualities, such as cyanide and mercury, are widely used as a consequence. Metals can be released into the environment due to acid drainage or an inadvertent release of metals from a mine tailing impoundment. While modest levels of heavy metals are necessary for many creatures' existence, high levels are harmful, and only a few terrestrial and aquatic species are known to be heavy metal resistant. On the other hand, some have changed over time. As the water content of heavy metals increased, so did the number of plant and animal species.

Salmon species, for example, are particularly vulnerable to rising quarry stone concentrations (Kelly, 2018). Furthermore, juvenile fish are more vulnerable to heavy metals than adult fish, and heavy metals have harmed fish at important reproductive and growth stages. In order to provide charcoal for pig-iron smelters, the mine has had indirect effects far from the mine site. According to Fearnside (2019), mining in the Brazilian jungle destroy 72,000 hectares of forest each year. The project will last for more than 250 years, (Fearnside, 2019). The mining sensitivity of a specific ecosystem was examined. The most visible impact of quarry stone mining on biodiversity is the destruction of vegetation, which has an impact on wildlife's access to food and shelter. Mining has altered the species mix and structure, which has harmed biodiversity on a greater scale. In an improvised aquatic habitat, acid drainage and high quarry stone concentrations are typically avoided; nevertheless, some organ and invertebrates are more tolerant of high quarry stone and acid exposure, and even thrive in a less competitive setting. Coal mine wells, for example, provide cover for bighorn sheep in mine-provided animal habitats, (MacCallum, 1989).

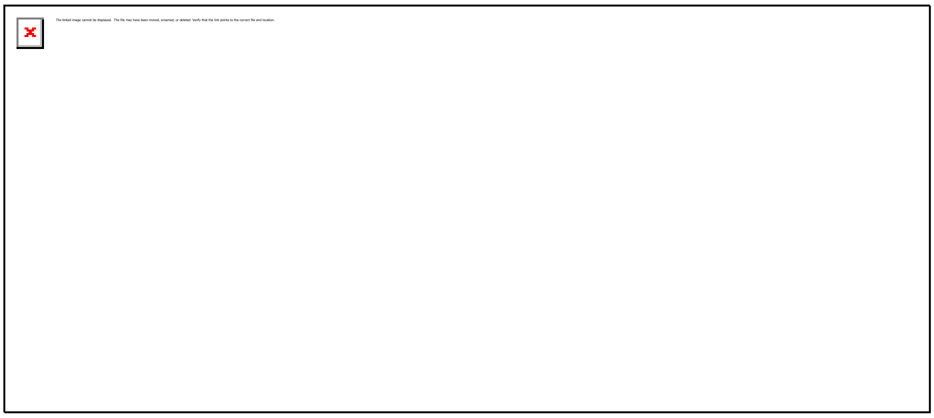

Figure 8. Initiatives to Reduce Negative Environmental Impacts

Respondents commented on the initiatives that can be taken to address the negative impacts of quarry stone mining (Fig 8). As can be seen in the figure above, re-settlement of affected communities (42.5%) was identified as the most effective strategy. By relocating households from the vicinity of quarry sites to safe grounds would address the challenges of noise, water and air pollution. This would drastically minimize health hazards posted by mining activities. Another approach is re-afforestation (31.8%) by the locals, county government and the area Kenya Forest Service (KFS). Issuing of seedlings by the KFS to restock the degraded areas especially the quarry sites would help in restoration of quarry pits and improving aesthetic beauty of these derelict lands left out by the excavators. Provision of alternative sources of drinking water (15.4%) was proposed as an important method of reducing the issues of water pollution witnessed in these areas. This could be realized through extending piped water supply to the unserved areas by concerned water service providers. Similarly introduction of water harvesting initiatives to the community would reduce the risk of water shortage or over-reliance on shallow sand pits and wells for water provision. Water springs from Nyambene ranges should be tapped and protected as important water source for safe human use.

Compensation (6.8%) of the affected communities was raised as a way of addressing los of land to quarry stone excavation especially by the private companies who lease such sites for scoping gravel for commercial purpose or contracted road construction companies. Compensation would take the form of cash or cash in lieu. Compensation helps address local resource-community conflicts and fights over the control, use and access to lands where quarry stones and river beds alluvial sand deposits. Lastly, constant review of operation methods used in mining (3.4%) would ensure adherence to good practices of quay stone excavation. This should be done by NEMA to audit local quarry sites safety and working conditions, methods of mining used and benefits accruing from such sites. This could be done through sensitization and capacity building of the involved stakeholders in mining. This is in line with observations made by Corbin (2018) that by-laws help in the sustainable management of stone resources.

Relationship between Spatial Distribution of Quarry Sites and Impacts of Mining Activities

Euclidean distance of sampled quarry sites with coded values of the impacts of quarrying operations were used to assess the validity of the proposed hypothesis concerning the relationship between the spatial distribution of mine sites and the consequences of mining activities on communities. The data was then analyzed using the rank correlation coefficient of spearman.

Table 3: Spearman's Rank Correlation Coefficient For Query Distribution and Associated Impacts

Quarry Distribution (X)	Rank X	Impacts (Y)	Rank Y	d =X-Y	d^2
10	1	6	5	-4	16
6	4	10	1	3	9
8	2	7	3	-1	1
3	3	4	2	1	1
3	5	2	4	1	1
∑ 30		∑ 30			∑ 28

By using the Spearman's Rank Correlation Coefficient (r_s)

$$r_s = I-\sum d^2/n(n^2-1)$$

$$r_s = 1-(28/5*(25-1)$$

$r_s = 1-0.23$
$r_s = 0.76$
df=5

There was a clear positive association between spatial distribution of quarry sites and impacts of mining activities on the populations of those sites, as determined by the computed rank correlation coefficient, rs=0.76, at P=0.01. This implies that the type of impact associated with quarry activities to the community and surrounding environment are largely influenced by spatial distribution of quarry mine sites.

Respondents have answered an important need to maintain the environment by overcoming significant barriers to environmental education and conservation (Mcduff, 2015). One of the most significant causes has been identified as environmental damage caused by stone quarrying (Mcduff, 2015). According to respondents' comments, during rainy seasons, 66 percent of the land population in the area is a hazard. Because of previous outbreaks of deseases, this has become a public health issue in the area. Meru's stone quarrying restrictions are not strictly enforced, resulting in significant soil damage. Tamale (2019) observes that, despite these restrictions and policies restricting land pollution, land contamination from quarrying is presently quite negligible. This is due to a variety of issues, including rising demand for other artificial stone for construction, mine exhaustion, tight laws for reading mines, and even a lack of sufficient quarrying skills. As a response, the government has begun an ongoing educational campaign to address the need to conserve the environment concerns associated with stone mining, but the impact has been too low to cause the considerable shift in public perception required to limit public participation in negative acts.

Three criteria were used to assess the suitability of the quarry environment: the availability, appropriateness, and safety of quarrying infrastructure, equipment, and materials. If a category's score was above the mean, it was declared suitable; if it was below the mean, it was deemed unsuitable. The physical environment was found to be unsuitable using these factors, as indicated in table 9 below.

Table 4: Suitability of Physical Environment for Stone Quarrying

Criteria of suitable of the environment	Level of suitability in the Environment			
	High (suitable)		Low (unsuitable)	
	Frequency	(%)	Frequency	(%)
Availability	17	42.5	23	57.5
Adequacy	27	67.5	13	32.5
Safety	18	45	22	55
Aggregate Suitability	18	45	22	55

According to table 9, the availability of the required physical infrastructure for quarrying was poor in 23 (57.5%) of the three settlements near the quarry. Fortunately, it was realized that the offered facilities were inadequate 13 (32.5 percent). As a result of this, the ecosystem suffers. The procedures employed to analyze the environment for safety were based on every signet ministry of minerals and environment (MOMB), which explains the findings. As a result of the findings, several quarrying towns in Meru County's Igembe South lack adequate facilities, equipment, and supplies. A huge majority of the existing facilities, equipment, and material were harmful and unsafe, according to the ministry of mining and minerals and the (NEMA) body's criteria. Some of the landslides that have occurred in the quarrying area were investigated by the researcher. After big storms, soil and stones are washed down the slope therefore large holes left over from stone mining, this happened. The ground has been stripped naked, and vast swaths of land have been wasted, dangling dangerously from the peaks. Stone miners are working deep down the slope, oblivious to the dangers that such quarries pose. The steep cliffs that remain have mostly been shifted, with the rest piled in the quarry. Landslides were sometimes followed by mass wasting, according to the data analysis.

V. CONCLUSION AND RECOMMENDATIONS

Conclusion

Mining's environmental consequences have been identified as environmental degradation and pollution. Stone quarrying in Igembe South Sub County has been linked to a number of public health problems in the surrounding communities. Stone query excavation has been linked to the loss of community natural resources, particularly vegetation cover and pollution. The environmental consequences of surface and underground mining, as well as the method of quarry stone extraction, include soil deterioration and contamination in various forms in the nearby villages of Igembe South mines (air, water, and noise). Surface (open pit) mining has generally resulted in soil damage due to the use of heavy machinery, toxic chemicals, and the placement of tailing dams.

Dust and other particle emissions, as well as chemical emissions such as carbon, sulfur, and arsenic from processing plants and waste disposal into tailing dams, have all contributed to air pollution. The primary effects of blasting quarry stones with explosives from both surface and underground mines are noise and vibration. Water pollution has resulted from the contamination of bodies of water with chemicals, dust, and other suspended particles. Most regions have degraded due to nutrient deficiency or have been set aside for activities, both of which have hampered food production. The annual agricultural yield of maize, cassava, beans, and yam decreased significantly. Water supplies in the communities are in poor condition, with the majority of them contaminated by waste from mining operations.

For its part, the Meru county administration has recognized the impact of mining activities on residents in mining villages and has worked to implement measures to mitigate and improve the people's environmental and socioeconomic consequences. To some extent, measures have been taken to improve conditions for residents in mining areas, such as reforestation of degraded land, review of operating methods, resettlement of affected communities, and provision of alternative drinking water sources, such as boreholes, to communities whose water resources have been contaminated with dust or to areas without water sources. The Environmental Protection Agency (EPA), whose primary mission is to ensure that mining operations comply with the law, has attempted to keep a close eye on the companies' activities. After a thorough review and study of the problem and all of its ramifications, as detailed in the previous chapters, it is critical to fix the environmental and social economic problems generated by mining operations. To ensure that the environmental effects of mining activities in the area are maintained to a bare minimum, Igembe South's environmental management department should resurrect its environmental management strategy. The miner tries to use and release as little harmful chemicals and other materials as possible in their activities, as long as the amount does not exceed E.P.A. guidelines, and without taking into account the negative environmental and social economic repercussions for the population.

Recommendations

The study makes the following recommendations:

Environmental assessment and audit programs should be periodically done to ensure compliance with good environment practice. Awareness creation and sensitization should be made a priority for the miners and local community on the benefits and impacts of excavation. There is need for the formulation of by-laws by the county government of Meru on exploitation of resources.Modernization of extraction should be done to improve efficiency and operations in the quarries. Compensation should be made to communities whose land has been acquired or degraded by mining activities. Consultative meetings should forged between the concerned departmental ministry and the locals to enhance public participation. Land reclamation should be done through vegetating excavated land and water drainage.

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