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KUMASI

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DEPARTMENT OF BUILDING TECHNOLOGY

ENVIRONMENTAL IMPACTS OF CONSTRUCTION AGGREGATE MINING IN THE GREATER ACCRA REGION

(A CASE – STUDY OF AMASAMAN IN THE GA WEST MUNICIPAL)

PROJECT SUPERVISOR: **MR. J. K OFORI – KURAGU**

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BY

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DECLARATION

This is to certify that this work or any part thereof has not been previously submitted in any form to the University or to any other body whether for the purpose of assessment, publication or for any other purpose. I confirm that except for any express acknowledgements and references cited in the work, the original work is the result of my own efforts.

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Signature…………………………… Date……………………………

DEDICATION

This work is dedicated to the glory of God, to my loving wife and children and to all lecturers in the Department of Building Technology.

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To God who is able to do exceedingly, abundantly above all that man can think, be all glory, honour and praise forever more, for granting me mercy, strength and wisdom to complete this work successfully. I am greatly indebted to my supervisor, Mr. J. K. Ofori – Kuragu, for his boundless patience in reading through my scripts, constructive criticisms, suggestions and contributions to the success of this work. I owe so much to everybody who made him/herself available for interviews and conversations.

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God bless them all.

ABSTRACT

Aggregates production from mining operations contributes significantly to the Ghanaian economy. New construction and rehabilitation of infrastructure require aggregates at an economically acceptable cost. However, environmental impacts from construction aggregate mining yield a significant effect on nature.

Aggregate mining in Ghana involves the extraction of unconsolidated sand, gravels, river stones, and crushed stones mainly for road and building construction. Stone quarrying activities like blasting, crushing and site clearance; sand and gravel mining activities like transportation, excavation, and site clearance are identified to have the most significantly severe environmental impacts. These activities give rise to atmospheric pollutants which degrade air quality and result in serious health consequences. Diesel fumes, fugitive dust blowing from construction aggregates, and increased traffic are identified as the major potential cumulative impacts from aggregate mining in Ghana. Health hazards arising from such impacts to mine workers, nearby residents, and the general public are identified as cold and catarrh, respiratory disorders, and asthma. Erosion of exposed areas, sedimentation associated with the use of heavy machinery, and loss of wildlife and plant habitats also identified to result in significantly severe ecosystem impacts, whilst noise, vibration and dust constitute significantly severe "public nuisance" effects. An exploratory study was conducted using structured questionnaire to identify the main environmental impacts of aggregate mining in Ghana, and measures to mitigate such impacts. The study used the random sampling method to select mine operators, nearby residents, and the general public for the study. Quantitative analyses were adopted for the environmental impacts and mitigating measures.

Aggregate miners in Ghana have no major reclamation programmes for degraded areas, and such areas are currently being used as landfills sites, refuse dumps, or are left for natural regeneration. Metropolitan, Municipal and District Assemblies (MMDAs) which have the primary authority for regulating aggregate mining operations should issue local permits and require performance bonds or some other form of financial assurance in order to ensure the enforcement of hours of operation, noise and dust mitigation measures, and reclamation programmes.

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LIST OF ABBREVIATIONS

MMDAs	Metropolitan, Municipal and District Assemblies
UEPG	Union Européenne des Producteurs de Granulats (European Aggregates Association)
PFA	Pulverized Fuel Ash
WRAP	Waste and Resources Action Programme
OWRRI	Oregon Water Resources Research Institute
UNCHS	United Nations Centre for Human Settlements
EPA	Environmental Protection Agency
NGOs	Non – Governmental Organizations
MS	Mean Score
SPSS	Statistical Package for Social Sciences
LI	Legislative Instrument
EIA	Environmental Impact Assessment
EPC	Environmental Protection Council

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CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND

Mining of natural aggregate, including both sand, gravel and crushed rock, represents the main source of construction aggregates used throughout the world, with examples from Australia (Erskine & Green, 2000), France (Petit, Poinsart & Bravard, 1996), Italy (Surian & Rinaldi, 2003), the USA (Kondolf, 1994), Belgium (Gob, Houbrechts, Hiver & Petir, 2005) and Britain (Sear & Archer, 1998). However, mining, whether small or large-scale, is inherently disruptive to the environment (Makweba & Ndonde, 1996). Also mining of aggregates frequently generates land use conflicts in populated areas due to its negative externalities including noise, dust, truck traffic, pollution and visually unpleasant landscapes (Willis & Garrod, 1999). It also lead to conflicts with competing need for other land uses such as farming, especially in areas where high-value farmland is scarce and where post-mining restoration may not be feasible. As pointed out by social and environmental activists there are potential linkages between mineral resources and conflict and consequential underdevelopment (Ross, 2001).

Gravel extraction can cause changes to channel morphology in rivers through the lowering of the riverbed during extraction (Rinaldi, Wyzga & Surian, 2005). This is enhanced by the disruption to bed armour caused by excavations and the movement of machinery which makes the bed vulnerable to fluvial erosion (Mossa & McLean, 1997).

In the Greater Accra Region of Ghana in particular where the land mass is already overpopulated, commercial gravel extraction to supply aggregates to the construction industry has been on the increase in recent years. This has to a large extent contributed to land degradation and desertification through the destruction of economically important trees, mostly indigenous in nature. This practice leaves behind bare soil and a large expanse of gullies which can collect water during rainy seasons. This can result not only in health–related problems for neighbourhood communities, but can cause negative impacts on the environment as well (Heath, Merefield & Paithankar, 1993; Veiga & Beinhoff, 1997; Warhurst, 1994, 1999).

Nonetheless, gravel sites from the study area are a particularly attractive source of aggregates as they are relatively well sorted, easily accessible and cheap to extract (Sear & Archer, 1998). This has potentially adverse impacts on the natural environment, society and cultural heritage, the health and safety of mine workers, and communities based in close proximity to operations (Moody & Panos, 1997) and dislocation (Akabzaa, 2000). While the people in general are familiar with the need and importance of sand and gravel mining for construction material, the awareness of the negative impact this has on the environment, biodiversity and food security may not be as commonly known.

Despite widespread occurrence and potential impact on the environment and agricultural lands, construction aggregate mining has received little attention. Even though some studies have improved our consciousness of the impacts, attention usually seems to be focused on mining along river banks.

1.2 STATEMENT OF THE PROBLEM

The World Commission on the Environment and Development (1987) report, Our Common future notes the increasing strain between the environment and economic development and calls for sustainable development as a reasonable means to achieve political, social and economic stability. The report defines “sustainable development” as the development “that meets the needs of the present without compromising the ability of future generations to meet their own needs”. It argues that a healthy and peaceful society cannot be achieved with widespread poverty and environmental degradation (World Commission on the Environment and Development, 1987).

In Ghana, aggregate extraction has been going on for some considerable time now, with production sites scattered in almost all regions across the country. As the construction industry’s activities constantly expands, there will continue to be a rise in the demand for construction aggregates but while these operations go on, their negative impacts on the environment continue to grow. Several studies have shown that there are some impacts on the environment from aggregate extraction with the most obvious or common impacts being physical and visual changes with others being difficult to identify since most impacts are engineering related. Other impacts include loss of habitat, blasting effects, noise, dust, erosion and sedimentation (Langer, 2001).

As the above indicate, aggregate mining for construction activities have been one of the serious environmental problems around the globe of which Ghana is not an exception in recent years. This often results in land degradation, loss of agricultural lands and biodiversity as well as increased poverty among people. In order to address these problems, pragmatic and explicit laws and regulations have to be developed by countries in a participatory manner so as to facilitate enforcement and compliance at all levels within the social settings.

1.3 AIM OF THE STUDY

The main aim of the research is to study the negative impacts that aggregate mining and processing has on the environment in Ghana and to propose measures that will help combat the problem.

1.4 OBJECTIVES OF THE STUDY

In order to achieve the research aim, the following objectives were set;

1. To identify the key environmental risks associated with construction aggregate mining in Ghana.
2. To establish communities' and stakeholders' perceptions on the environmental impacts of aggregate mining for construction in Ghana.
3. To assess the impact of the enforcement of statutory regulatory provisions and policies governing construction aggregate mining in Ghana by Environmental Protection Agency.
4. To suggest interventions that could assist in mitigating the negative impacts of aggregate mining for construction in Ghana.

1.5 SIGNIFICANCE OF THE STUDY

The findings of this research will be used to educate construction aggregates miners or mining firms on the need to mitigate the effects of construction aggregate mining on the environment. Also, it would be used to inform policy makers concerning impacts of construction aggregate mining on the environment.

1.6 SCOPE OF THE STUDY

The study focused on construction aggregates miners or mining firms in the Greater Accra Region of the Ghanaian construction industry. These miners or mining firms were targeted because their activities have negative impact on the environment. In addition, the views of residents in Amasaman of the Ga West municipal Assembly of the Greater Accra Region were also sought on the negative impacts of construction mining activities and remedies that may be adopted to address them.

1.7 METHODOLOGY

Published books, journals and articles as well as information from the internet formed the basis of the literature review section.

The study was undertaken using questionnaire based survey in which both closed ended and open ended questions were designed and administered. Interviews were also conducted with environmental protection agency and environmentalists to gather information on their views on the impact of construction aggregate mining on the environment with particular reference to Amasaman, the municipal capital of the Ga West Municipal Assembly in The Greater Accra Region.

The data collected was analysed using Statistical Package for Social Sciences (SPSS) software.

1.8 OUTLINE OF THE STUDY.

The research was made up of five chapters as follows;

- **Chapter One: Introduction**

This chapter shows the general background of the study, the problem statement, and main objectives of the research, justification or the significance of the research, the scope of the research and a general overview of the methodology that was used to carry out the study.

- **Chapter Two: Literature Review**

This chapter shows a historical review of related literature from previous studies to identify the impact of construction aggregate mining on the environment.

- **Chapter Three: Methodology**

This chapter shows the main methodologies used in previous studies and the methodology that was used in this research in order to achieve the desired objectives. This included the use of questionnaires, interviews, observations and interactions with construction aggregates miners within the Greater Accra Region, the residents of Amasaman in the Ga West Municipal Assembly as well as the Environmental Protection Agency.

- **Chapter Four: Results analysis**

This chapter shows clearly, the analysis, description and discussion of research results that were attained through the data collected. This chapter also discussed the findings of the research in line with the aims and objectives that will guide the entire research.

- **Chapter Five: Conclusion and Recommendations**

This final chapter of the research drew conclusions on the major findings of the study and gave related recommendations to minimise the impact of construction aggregate mining activities on the environment.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

Aggregates are granular material used in construction for their granularity. The most common natural aggregates of mineral origin are sand, gravel and crushed rock. They are produced from natural sources extracted from quarries and gravel pits and in some countries from sea-dredged materials (UEPG, 2009). Construction aggregates have played a major role in advancing engineering construction projects for many years, and improved concrete construction has provided a steady advance in economic progress (West and Cho, 2006).

Aggregates are crucial resources for the infrastructure development activities, such as road building and concrete production. For example, 1 m^2 of built area consists of about 2 tons of aggregates; the construction of one house uses up to 400 tons of aggregates; the construction of 1 km of motorway uses up to 30,000 tons of aggregates and the construction of 1 meter of railway for a High Speed train uses up to 9 tons of aggregates (UEPG, 2009).

Aggregates are subdivided into three types:

1. Primary aggregates (which are extracted from geological deposits)
2. Secondary aggregates (which are taken from industries in non-construction sector)
3. Reused and recycled aggregates (which were previously used in construction)

Primary aggregates include the following types of materials:

1. Rock, which may be subdivided into crushed rock and cut and broken rock. Crushed rock is mainly used for aggregate production (Meulen et al, 2003);
2. Sand, which is used for concrete and mortar production;
3. Gravel: mostly rounded stony material, which is used for concrete production and as a drainage media (Meulen et al, 2003);
4. Soil materials are mostly used as a filling material.
5. Clay is also considered as soil materials (McNally, 1998).

Secondary aggregates are earthy and stony waste materials and industrial by – products, used as alternatives to primary materials (Meulen et al, 2003). Secondary aggregates are divided into manufactured and natural depending on their sources. Examples of manufactured secondary aggregates are pulverized fuel ash (PFA) and metallurgical slags. Natural secondary aggregates include china clay sand and slate aggregate (WRAP, 2009). Secondary aggregates are used for such products as ready-mixed concrete (made of 80% aggregates), pre-cast products, asphalt (made of 95% aggregates), lime and cement (UEPG, 2009).

Recycled aggregates are produced from a variety of material: arising from construction and demolition (concrete, bricks, tiles), highway maintenance (asphalt planings), excavation and utility operations. There are two methods of producing recycled aggregates: in situ (at the site of the arisings), or offsite in a central plant (WRAP, 2009).

2.1 CONSTRUCTION AGGREGATE

Construction aggregate or simply "*aggregate*" is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geo - synthetic aggregates (Langer, 2001). Aggregates for construction are the most mined material in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material (Langer, 2001). Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates are also used as base material under foundations, roads, and railroads. To put it another way, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building), or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.

2.1.1 Types of Aggregates

According to Chudley (1994), Aggregates are divided into two types as fine and coarse aggregates.

Fine Aggregate: "Fine aggregate is defined as material which passes a 5 mm sieve" (Chudley, 1994). For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

Coarse Aggregate: Coarse aggregate according to Chudley (1994) is a material that will be retained on the 5 mm sieve. Even though the definition seems to limit the size of coarse aggregate, other considerations must be accounted for.

Also, According to Langer (2001) a lot of materials are classified as aggregates, but those obtained from mineral deposits are mostly associated with construction, these being

- ❖ Stone (granite, limestone and dolomite)
- ❖ Sand and gravels

Construction Aggregates, when properly proportioned and mixed with cement, these two groups yield an almost void less stone that is strong and durable. In strength and durability, aggregate must be equal to or better than the hardened cement to withstand the designed loads and the effects of weathering (www.tpub.com Accessed 4th November, 2011). It can be readily seen that the coarser the aggregate, the more economical the mix. Larger pieces offer less surface area of the particles than an equivalent volume of small pieces. Use of the largest permissible maximum size of coarse aggregate permits a reduction in cement and water requirements. One restriction usually assigned to coarse aggregate is its maximum size. Larger pieces can interlock and form arches or obstructions within a concrete form that allows the area below to become a void, or at best, to become filled with finer particles of sand and cement only. That result in either a weakened area or a cement sand concentration that does not leave the proper proportion to coat the rest of the aggregate. The capacity of the mixing equipment may also limit the maximum aggregate size (www.tpub.com Accessed 4th November 2011).

2.1.1.1 Stone

In geology, rock or stone for construction is a naturally occurring solid aggregate of minerals.

According to Mckay (1989), The Earth's outer solid layer, the lithosphere, is made of rock. In general, rocks are of three types, namely, igneous, sedimentary, and metamorphic. Rocks are generally classified by mineral and chemical composition, by the texture of the constituent particles and by the processes that formed them. These indicators separate rocks into igneous, sedimentary, and metamorphic. Rocks, according to Mckay (1989), are further classified according to particle size. The transformation of one rock type to another is described by the geological model called the rock cycle.

Igneous rocks are formed when molten magma cools and are divided into two main categories: plutonic rock and volcanic. Plutonic or intrusive rocks result when magma cools and crystallizes slowly within the Earth's crust (example granite), while volcanic or extrusive rocks result from magma reaching the surface either as lava or fragmental ejecta (examples pumice and basalt) (Blatt et al, 1996).

Sedimentary rocks are formed by deposition of either clastic sediments, organic matter, or chemical precipitates (evaporites), followed by compaction of the particulate matter and cementation during diagenesis. Sedimentary rocks form at or near the Earth's surface. Mud rocks comprise 65% (mudstone, shale and siltstone); sandstones 20 to 25% and carbonate rocks 10 to 15% (limestone and dolostone) (Blatt et al, 1996).

Metamorphic rocks are formed by subjecting any rock type to different temperature and pressure conditions than those in which the original rock was formed. These temperatures and pressures are always higher than those at the Earth's surface and must be sufficiently high so as to change the original minerals into other mineral types or else into other forms of the same minerals (Blatt et al, 1996).

The three classes of rocks— igneous, sedimentary and metamorphic—are subdivided into many groups. There are, however, no hard and fast boundaries between allied rocks. By increase or decrease in the proportions of their constituent minerals they pass by every gradation into one another, the distinctive structures also of one kind of rock may often be traced gradually merging into those of another. Hence the definitions adopted in establishing rock nomenclature merely correspond to selected points (more or less arbitrary) in a continuously graduated series (Blatt et al, 1996).

Figure 2.1 A heap of stones (source: Personal Collection)

2.1.1.2 Sand

According to Barry (1999), sand for construction is natural sediment of granular, mainly siliceous, products of rock weathering. Particles are smaller than 2 mm, are visible to the naked eye and the smallest particle is 0.06 mm. Construction sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica

(Silicon dioxide, or SiO_2), usually in the form of quartz.

According to the Barry (1999), as the term is used by geologists, sand particles range in diameter from 0.0625 mm (or 1⁄16 mm, or 62.5 μm) to 2 mm. An individual particle in this range size is termed a sand grain. The next larger size class above sand is gravel, with particles ranging from 2 mm up to 64 mm. The next smaller size class in geology is silt: material between 60 μm and 2μm (Neville, 1997). A 1953 engineering standard published by the American Association of State Highway and Transportation Officials set the minimum sand size at 0.074 mm while a 1938 specification of the United States Department of Agriculture was 0.05 mm (Urquhart and Church, 1959). Sand feels gritty when rubbed between the fingers (silt, by comparison, feels like flour).

ISO 14688 grades sands as fine, medium and coarse with ranges 0.063 mm to 0.2 mm to 0.63 mm to 2.0 mm. In the United States, sand is commonly divided into five sub-categories based on size: very fine sand ($^1/_{16}$– $^1/_8$ mm diameter), fine sand ($^1/_8$ mm –$^1/_4$ mm), medium sand ($^1/_4$ mm–$^1/_2$ mm), coarse sand ($^1/_2$ mm – 1 mm), and very coarse sand (1 mm – 2 mm) Barry (1999).

Figure 2.2 A heap of sand (source: Personal Collection)

2.1.1.3 Gravel

According to Hogan (2010), gravel for construction is an important commercial product, with a number of applications. Many roadways are surfaced with gravel, especially in rural areas where there is little traffic. Globally, far more roads are surfaced with gravel than with concrete or tarmac; Russia alone has over 400,000 km (250,000 mi) of gravel – surfaced roads. Both sand and small gravel are also important for the manufacture of concrete. Large gravel deposits are a common geological feature, being formed as a result of the weathering and erosion of rocks. The action of rivers and waves tends to pile up gravel in large accumulations. This, Hogan (2010) states can sometimes result in gravel becoming compacted and concreted into the sedimentary rock called conglomerate. Where natural gravel deposits are insufficient for human purposes, gravel is often produced by quarrying and crushing hard-wearing rocks, such as sandstone, limestone, or basalt. Quarries where gravel is extracted for construction purposes are known as gravel pits. Southern England possesses particularly large concentrations of them due to the widespread deposition of gravel in the region during the Ice Ages (Hogan, 2010).

Gravel is composed of unconsolidated rock fragments that have a general particle size range and include size classes from granule- to boulder-sized fragments. Gravel can be sub-categorized into granule (>2 to 4 mm or 0.079 to 0.16 in) and boulder (>64 to 256 mm or 2.5 to 10.1 in). One cubic yard of gravel typically weighs about 3000 pounds (or a cubic meter is about 1,800 kilograms) (Hogan, 2010).

2.2 AGGREGATE MINING

According to Langer (2002), Aggregate – sand, gravel, and crushed stone – is the number one non–fuel mineral resource in the United States and the World in terms of volume and value. Every developed and developing country produces aggregate. In the United States, there are nearly 10,000 active pits and quarries. It is becoming increasingly difficult to mine aggregate due to conflicting land uses, zoning, citizen opposition, inability to obtain permits, and environmental issues. Nevertheless, it is estimated that more aggregate will need to be produced during the next 25 years than has been mined during the previous 100 years. While aggregate extraction is an on – going source of aggravation for local communities and a serious concern among some environmentalists, the broad importance of aggregates to our built environment and economy cannot be overlooked. The challenges associated with the aggregates industry have remained largely the same since the 1970s. According to Poulin, Pakalnis and Sinding, (1994), aggregates are considered an essential good with a low per tonne cost, which imposes a significant impact on landscapes. The need to minimize transportation costs has in most cases meant that aggregate extraction sites and related facilities are often located near population centres. This has been described by some researchers as the paradox of the aggregate industry: a steady and predictable demand for aggregates combined with local populations who would prefer mining operations to be located in more remote areas (Poulin, Pakalnis and Sinding, 1994).The extraction of aggregate resources can cause significant environmental damage and has the potential to negatively impact human health and quality of life, especially if producers do not follow mitigation measures. According to Capita-Symonds Ltd (2006), aggregate extraction operations are defined as either pits or quarries. The distinction between pits and quarries is made based on the type of materials extracted. Unconsolidated materials such as sand and gravel are extracted from pits, while consolidated materials such as limestone and granite are extracted from quarries. Pits are in some cases smaller scale operations with less significant impacts, but vary widely in size across the districts. Capita – Symonds Ltd (2006) notes that quarries are often more substantial operations and may have more significant environmental and social impacts. If aggregate extraction will be occurring at a depth that extends below the water table, the pit or quarry must also be dewatered by pumping the inflow of groundwater out of the excavated area.

2.2.1 Stone Extraction

According to Mckay (1992), the methods adopted in quarrying stone vary and depend upon the type and its depth below the surface. Mckay (1992) further states that most stone is obtained in open quarries, but where it is very deep (such as Bath Stone) underground mining is used.

According to Langer et al (2004), mining crushed stone differs from mining sand and gravel because the bedrock, in most situations, must first be drilled and blasted. The technology of blasting rock is highly developed and regulated. Holes are drilled into the rock and are partially filled with explosives. The top portion of the hole is filled with non-explosive material (usually sand, crushed stone, or a manufactured plug) that is referred to as "stemming." The explosive in each hole is initiated with detonators that create delay periods between blasts in individual holes. The total blast commonly lasts only a fraction of a second and consists of many smaller individual blasts separated by delays of a few thousandths of a second.

For thousands of years man has used stone for building, whether it was for monuments, religious buildings or houses. Early on, when Britain was only sparsely populated, man's use of stone and his primitive quarrying would have had little lasting impact on the environment. Gradually, as time went on, more stone was used in building. It was a good material with which to build castles, walls, churches and important buildings since it was strong and weather resistant. As the demand for stone grew, so did the demand for quarrying. During the Industrial Revolution demand soared. The Victorians used stone for all their major buildings and with better transport and new technology they were able to meet these increasing demands, probably with little thought as to their impact on the environment (Langer et al 2004).

Today the demand for carefully worked stone for building has been reduced by the fact that we have so many new, easier to use and cheaper building materials but this does not necessarily mean that there is less quarrying. Although stone blocks are not used so much for building as they used to be, we still use stone in a different form for building and construction work today (Langer et al 2004).

There is now a great demand for stone, especially limestone in the form of 'crushed rock' and it is also an essential constituent in other building and construction materials. Creating one kilometre of road 10 metres wide could use well over 500 lorry loads of crushed stone.

Because the stone used for this sort of construction work does not have to be extracted in a high quality block form, the techniques for quarrying have changed. Now, those that quarry can be less selective. Consequently one of the best methods of quick quarrying is the use of explosives which means that great chunks of hillsides may be blown up and transported away in a relatively short time (Langer et al 2004).

Sand and gravel are used along with stone in construction work. Consequently millions of tonnes are being removed from sand and gravel deposits both on land, usually close to the urban areas where they are needed, and also from the sea bed. Aggregate mining produces materials that are used in road and building construction (e.g. sand, gravels, base course, crushed rock etc.), landscaping (e.g. topsoil, fill, dimension stone etc.), and other general construction uses (Blodgett, 2004).

According to Blodgett (2004), whilst a quarry is in use the effects on the local environment are more than just the loss of wildlife habitats and the obvious visual impact. A working quarry needs methods of transportation and this means that large amounts of machinery and heavy traffic will be brought into the area, causing an increase in local noise, pollution and erosion.

Stone quarries come in different shapes and sizes. Some, like the gravel pits are relatively easy to reclaim. Many disused quarries, once they have been made safe, are used for leisure areas such as camp sites or motor vehicle racing tracks but the reclamation of others is more difficult.

Removal of vast quantities of rock can change the very shape of our environment. Whole hillsides can be destroyed and layers of valuable soil removed (Blodgett, 2004).

Since 1981, there has been a time – limit imposed on those who seek to extract stone from the land. They are not allowed to quarry for an indefinite amount of time. Companies are also required to 'reinstate' the land – this can involve years of careful drainage and land management in order to get the area back to a state where it can be used.

Any amount of careful management, however, will not return the land to the way it was before the rock was extracted and the species of flora and fauna that were disturbed and destroyed may never be able to re – establish themselves in that area again.

Figure 2.3 A stone extraction operation (source: Personal Collection)

2.2.2 Sand Extraction

The mining of sand for construction materials has been practiced for centuries. These extraction areas have often been abandoned with little or no reclamation effort, particularly areas mined before the 1980's. Spoils from sand mining are generally coarse textured, and mineralogically heterogeneous. They are low in organic matter, have little or no structure, and are deficient in plant nutrients. Without some amelioration, any plants grown on these spoils are susceptible to water, temperature, and nutrient stresses (Hornick, 1982). Sand mining is a practice that is becoming an environmental issue as the demand for sand increases in the building industry and construction. Sand is mined from beaches and inland dunes and dredged from ocean beds and river beds. It is often used in manufacturing abrasives, for example sand paper, and it is used to make concrete. As communities grow, construction requires less wood and more concrete, leading to a demand for low-cost sand. Sand is also used to replace eroded coastline (Hornick, 1982).

According to Hornick, (1982), sand mining is a direct and obvious cause of erosion, and also impacts the local wildlife. For example, sea turtles depend on sandy beaches for their nesting, and sand mining has led to the near extinction of ghariyals (a species of crocodiles) in India. Disturbance of underwater and coastal sand causes turbidity in the water, which is harmful for such organisms as corals that need sunlight. It also destroys fisheries, causing problems for people who rely on fishing for their livelihoods.

Removal of physical coastal barriers such as dunes leads to flooding of beachside communities, and the destruction of picturesque beaches causes tourism to dissipate. Sand mining is regulated by law in many places, but is still often done illegally (Hornick, 1982).

***Figure 2.4** A Sand Extraction Operation at Amasaman (source: Personal Collection)*

2.2.3 Gravel Extraction

According to the Oregon Water Resources Research Institute [OWRRI] (1995), when the rate of gravel extraction exceeds the rate of natural deposition over an extended time period, a net cumulative loss of gravel occurs. Kondolf, (1998) proposes three types of instream gravel mining, described as dry-pit and wet – pit mining in the active channel, and bar skimming (or "scalping"). Dry-pit according to Kondolf, (1998) refers to excavation on dry ephemeral stream beds and exposed bars with conventional bulldozers, scrapers, and loaders.

Figure2.5 A dry pit gravel extraction operation (source: Personal Collection)

Wet-pit mining involves the use of a dragline or hydraulic excavator to remove gravel from below the water table or in a perennial stream channel. Bar skimming or scalping removes the surface from gravel bars without excavating below the low water flow level. In addition to the instream mining described above, Kondolf, (1998), also proposes another method, which involves the excavation of pits on the adjacent floodplain or river terraces (Kondolf, 1998). Pits located above the water table are also known as dry-pits, whereas wet-pits are below, depending on the elevation of the floodplain or terrace relative to the base flow water elevation of the channel. The isolation of these pits from an adjacent active channel may be only short-term. During a sudden change in channel course during a flood, or as part of gradual migration, the channel may shift into the gravel pits (Kondolf 1998). Because floodplain pits can become integrated into the active channel, Kondolf (1994) suggests that they should be regarded as part of the active channel if considered on a time scale of decades, and managed accordingly. Winfield and Taylor (2005), however classifies gravel extraction into open – pit mining and extractive methods of mining. Open-pit mining or opencast mining refers to a method of extracting rock or minerals from the earth by their removal from an open pit or borrow.

The term is used to differentiate this form of mining from extractive methods that require tunneling into the earth. Open-pit mines are used when deposits of commercially useful minerals or rock are found near the surface; that is, where the overburden (surface material covering the valuable deposit) is relatively thin or the material of interest is structurally unsuitable for tunneling (as would be the case for sand, cinder, and gravel). For minerals that occur deep below the surface—where the overburden is thick or the mineral occurs as veins in hard rock—underground mining methods extract the valued material.

Open-pit mines that produce building materials and dimension stone are commonly referred to as quarries. People are unlikely to make a distinction between an open-pit mine and other types of open-cast mines such as quarries, borrows, placers, and strip mines.

Open-pit mines are typically enlarged until either the mineral resource is exhausted, or an increasing ratio of overburden to ore makes further mining uneconomic. When this occurs, the exhausted mines are sometimes converted to landfills for disposal of solid wastes. However, some form of water control is usually required to keep the mine pit from becoming a lake (Winfield and Taylor, 2005).

***Figure** 2.6 A disused gravel pit at Amasaman (source: Personal Collection)*

2.3 ENVIRONMENTAL IMPACTS

Mason and Welgoss (2002) stated that both environmental and economic complications may develop due to the extraction of construction aggregates. Aggregate is mined from the earth, either dug out of pits or blasted out of quarries. This process has many significant environmental impacts (Winfield and Taylor, 2005). Creating the pits or quarries requires the removal of virtually all natural vegetation, top soil and subsoil to reach the aggregate underneath. Not only does this lead to a loss of existing animal wildlife, it also leads to loss of plants and aquatic habitats. Moreover, adjacent eco-systems are affected by noise, dust, pollution and contaminated water. Pits and quarries disrupt the existing movement of surface water and groundwater; they interrupt natural water recharge and can lead to reduced quantity and quality of drinking water for residents and wildlife near or downstream from a quarry site.

Most old pits and quarries are not being properly rehabilitated. As noted in one study "less than half of the land disturbed for aggregate production between 1992 and 2001 has actually been rehabilitated" (Winfield and Taylor, 2005). The district classifies pits and quarries as "interim uses of the land" and requires 100% rehabilitation of pits and quarries. Clearly this requirement is not being met. Destroyed ecosystems and source water aquifers are irreplaceable. This is not an interim land use. The landscape is blotted with destructive pits and quarries, and species of all kinds endure permanent negative impacts.

A more detailed picture of the environmental impact of aggregate mining is outlined in a 2005 legal challenge to the expansion of an existing quarry in the Niagara Escarpment. The report focuses on the following potential environmental impacts (Castrilli, 2005).

- Potential impairment of water quality on the site, including harm to the aquifer
- The water quality of residential wells close by could be harmed
- The water level of on-site lakes could be reduced, detrimentally affecting provincially specific wetlands

- Heightened summer water temperature in an on-site lake could have a detrimental impact on the viability of cold water fish in an adjacent stream. Potential harm to on-site and off-site wetlands.
- Potential loss and fragmentation of continuous natural environment

Of course, each pit or quarry has unique characteristics and impacts, but every pit or quarry will degrade the natural environment. For pits or quarries situated on lands designated as ecologically significant, this degradation has an even greater adverse impact.

For communities, the displacement of water resources is one of the biggest concerns pits and quarries pose. However, there are many other concerns. Beyond the physical changes to the landscape, the daily barrage of noise, dust and exhaust produced by hundreds of dump trucks hauling aggregate can have serious effects on the health of people living nearby. Chrisna (2002), stated that as long as the construction industry demands natural resources, it will continue to impact the physical environment; and such impacts will assume huge environmental significance with the rapid growth in population and the attendant implications for natural resources. In the opinion of Chrisna (2002), the call and desire for sustainable construction is in realization of the construction industry's capacity to make a significant contribution to environmental sustainability because of the enormous demands it exerts on global resources.

According to Section 30(1) of the Environmental Assessment Regulations (1999), environmental impact includes any direct or indirect, positive or negative change in the environment caused by man-made works or activity when such change affects life in general, biodiversity, the quality or a significant quantity of natural or environmental resources and their use, well-being, health, personal safety, habits and customs, the cultural heritage or legitimate means of livelihood.

Langer (2002) also states that extracting aggregate resources causes environmental impacts, most of which are relatively benign. Aggregate extraction seldom produces acidic drainage that may be associated with mining of metallic or energy resources. Other serious environmental health hazards are rare. Some environmental impacts from aggregate extraction are engineering – related. The most obvious impact is the physical changes to the landscape. These impacts can be accompanied by loss of habitat, blasting effects, noise, dust, erosion, and sedimentation. There is a concern about health impacts associated with crystalline silica and naturally occurring asbestos in dust generated during aggregate extraction and processing. According to Langer (2002), some geologic environments, such as active stream channels, karst areas, and ground-water systems in general, are dynamic and respond rapidly to outside stimuli. In these environments, aggregate mining can alter the dynamic equilibrium of the area resulting in cascading environmental impacts. Failure to adequately address environmental issues can lead to serious, long-lasting, and irreversible environmental consequences, either in the vicinity of the site or at locations distant from the site.

According to Fry (2007) aggregate transportation generates about 20% – 40% of the total carbon dioxide emissions produced by the aggregate industry as a whole. Moreover aggregates have destructive environmental impacts on the local environment. Such impacts are visual intrusions, noise, air, water and soil pollution and loss of biodiversity (Solar et al., 2007).

2.3.1 Impact on Air Quality

According to Blodgett, (2004), the most obvious environmental impact from construction aggregate mines is degraded air quality, and associated health effects, resulting from airborne emissions from both the stack and the disturbed areas at these mines. The construction process gives rise to many atmospheric pollutants. Quarrying, for example, causes air pollution from dust and fumes. Ofori et al. (1999) asserted that the most obvious environmental impact from aggregate mining is degraded air quality and associated health effects resulting from the stack and the disturbed areas at the mines. In a country such as Ghana, the impacts of such mines on surface and groundwater quality are likely to be significant.

Below is a partial list of the potential impacts proposed by Blodgett, (2004) from the development of typical sand and gravel mines;

- Dust and diesel fumes generated on the haul road to and from the quarry sites or mines.
- Fugitive dust blowing from the uncovered or partially covered dump trucks.
- Fugitive dust from poorly monitored crushers and out-of-compliance operations.
- Fugitive dust from piles of sand and gravel at the quarry sites or mines
- Fugitive dust from the spreading of sand and gravel at the construction site, whether highway or building construction.
- Increased traffic (highways) or population (building construction), with a concomitant increase in air pollution from more vehicles (highways and rural roads) and more disturbed land (building construction).
- Increased air pollution from some sand and gravel mines after they are abandoned and until natural re–vegetation stabilizes the surface soil.

Each of the impacts listed above produces real – world effects that are difficult to measure.

According to Langer et al (2004) however the word “dust” is used generically to describe fine particles that are generally less than 75 microns (µm) in diameter and that can be transported in the atmosphere. Dust in the urban environment commonly includes sources from industry, vehicles, coal and wood smoke, and particles from the soil. Typically, the dust associated with aggregate operations consists of particles from exposed soil and rock.

The presence of dust, according to Langer et al (2004), sometimes raises concerns that are not directly proportional to its impact on human health and the environment. Dust concentrations, deposition rates, and potential impacts tend to decrease rapidly away from aggregate operations. Federal, state, and local regulations put strict limits on the amount of airborne material that may be released from an aggregate site, especially dust that could be inhaled. Blasting, excavation, loading and unloading material, stockpiles, and haul roads may be nonpoint sources of “fugitive” dust. Point sources, such as drilling, crushing, screening, and conveying, may also generate dust. Site conditions, including rock properties, moisture, ambient air quality, air currents and prevailing winds, the physical size of the operation, production levels, and other nearby sources of dust, affect the amount of dust generated during aggregate mining.

In the past, smaller populations and lower levels of development made these impacts less noticeable. But with larger populations and development that consistently outstrips the government’s ability to regulate its impacts, the cumulative effects of aggregate and stone mining, especially in urban areas, contribute to the overall degradation of the environment. In rural areas these impacts are also serious for affected local communities (Langer et al, 2004).

The impacts from operations-generated dust commonly can be mitigated through process design and engineering and by the use of dry dust collection or wet suppression systems. Controlling fugitive emissions commonly depends on good housekeeping practices. Measures proposed by Langer et al (2004) to reduce dust include;

- Controlled blasting;

- ❖ Careful location of process equipment and stockpiles;
- ❖ Dust collection on drill rigs and stationary process equipment;
- ❖ Use of telescopic chutes, dust skirts, and screen covers;
- ❖ Reducing drop height of dusty material;
- ❖ Use of sweepers;
- ❖ Water or chemical applications on haul roads and rubble piles
- ❖ Control of vehicle speeds; and
- ❖ Construction of windbreaks, buffer zones, and plantings.

The creation of buffer zones and construction of windbreaks and plantings can restrict transport of dust. Dry dust collection systems include the use of enclosures and covers on conveyors, screens, and crushers and the use of vacuum systems and bag houses, which remove dust before the air stream is released to the atmosphere. Wet dust suppression systems consist of pressurized water (or surfactant treated water) sprays located at dust-generating sites, such as conveyors, crushers, and screens. Suppression systems can also be used to wet loads before vehicles leave the construction aggregates mine site (Langer et al, 2004).

Figure 2.7 Dust generated on a haul road (source: Personal Collection)

2.3.2 Impact Due to Noise on the Environment

The primary sources of noise from aggregate extraction are blasting, earth-moving equipment, processing equipment, and truck traffic. Sound travels farther in dense, cold air than in warm air, and when there are atmospheric inversions. The impacts of noise according to Langer et al (2004) depend on:

- Sound source;
- Topography, land use, and ground cover of the surrounding site;
- Climatic conditions; and
- Sensitivity of receivers.
- The beat, rhythm, and pitch of noise affect the impact of the noise on the receiver.

The accustomed level of background noise is an important factor in determining a person's tolerance to a new noise. In an urban or industrial environment, back-ground noise may mask noise from an aggregate operation, whereas the same level of noise from an operation in a rural area or a quiet residential neighbourhood may be more noticeable. If a specific noise is identifiable, it tends to be noticed. For example, the noise from a single truck can commonly be distinguished from an equally loud volume created by automobile traffic.

Aggregate operators are responsible for assuring that the noise emitted from the operations does not exceed the level set by regulations. Some of the measures proposed by Langer et al (2004) are that Acoustic maps can be prepared to chart sound sources and determine corrective action so that the impacts of noise can be mitigated through various engineering techniques. Means for limiting noise from mobile equipment include the use of mufflers, "smart" backup alarms that adjust their volume relative to ambient noise levels, broadband alarms, and the use of strobe light back-up alarms at night. Selecting low-noise plant equipment, such as rubber or urethane screens and chute liners, flexible equipment mounting systems, and locating noisy equipment in sound-deadening (acoustical) enclosures can help limit noise from stationary equipment.

Equipment can be located so that naturally vegetated areas, quarry walls, or topographic barriers shield or absorb noise. Berms, landscaping, and stockpiles can be used to form sound barriers. Conveyors can be used instead of trucks for in-pit movement of materials. The proper location of access roads, the use of acceleration and deceleration lanes, and careful routing of trucks can help reduce truck noise. Noisy operations can be scheduled or limited to certain times of the day (Langer et al, 2004).

Aggregate operations have the potential to negatively impact human health and quality of life due to the amounts of noise, dust and vibration associated with quarrying activities and transportation of aggregates from the site. Particulate matter released during extraction and processing may also be a human health hazard if it is not properly controlled (Birch, Datson and Lowndes, 2008).

2.3.3 Impact on Landscape and Habitat

Site clearance and excavation are site activities which have been found to result in the loss of wildlife and native plant habitat (Teixeira, 2005; Uher, 1999; U.S. Environmental Protection Agency, n.d.). Aggregate mining for construction are mostly obtained from the natural environment; it is quite hard for its extraction not to have any effect on natural habitat. According to Langer et al (2004), some ecosystems underlain with aggregates serve as habitat for rare and endangered species of plants or animals. The UNCHS (1993) estimated that quarrying accounts for a significant proportion of total land loss in urban areas. Therefore mining aggregate for construction in such places could lead to the extinction of these endangered species. Once a suitable deposit has been located, it usually developed to a pit or quarry. This in one way or the other brings changes to the landscape for example inland sand sites would usually be stripped of its entire vegetation leaving the site vulnerable to weather which in turn destabilizes the ground leading to erosion. Although erosion and runoff are natural processes, they are not necessarily favourable. Sediment, debris and chemicals such as petroleum products can be washed into waterways, potentially damaging water supplies and aquatic life (Relf, 2001).

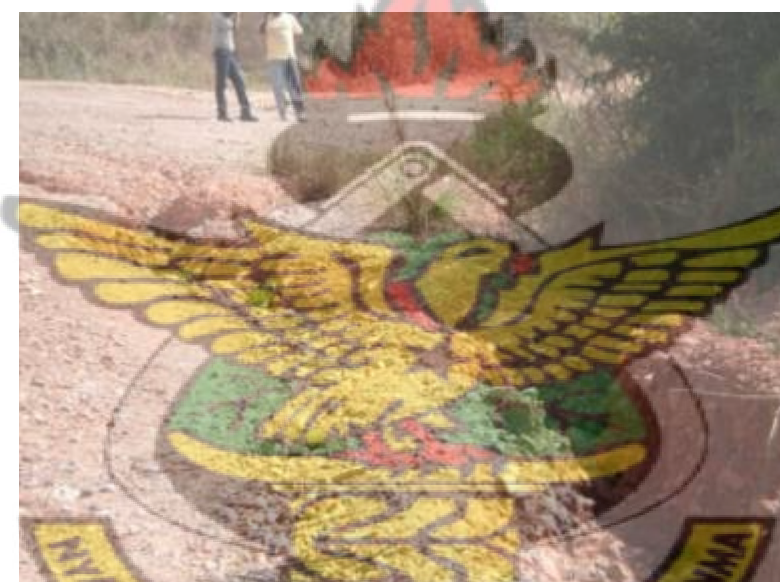

Figure 2.8** Erosion due to Gravel Extraction Operation (source: Personal **Collection)

2.4 ENVIRONMENTAL LAWS

In Ghana in recent decades, land degradation and the environmental burden from the extraction of natural resources and related activities have been significant (Akabzaa, 2000; Awudi, 2002; International Monetary Fund, 2004). Since the early 1990s the government has taken substantial action to address these challenges. In 1991, Ghana adopted a National Environmental Policy for "ensuring a sound management of resources and the environment, and to avoid any exploitation of these resources in a manner that might cause irreparable damage to the environment" (Ebenezer, 1991). In 1994, the Environmental Protection Council, in collaboration with the Minerals Commission, adopted guidelines mandating environmental impact assessment for mining activities in the country (Minerals Commission and Environmental Protection Council, 1994). According to the policy, environmental impact assessments must ensure that companies that deal with sand and gravel mining "demonstrate that the project has been planned in an environmentally sensitive manner and that appropriate pre-emptive or mitigative measures and safeguards have been integrated into the project's design" (Minerals Commission and Environmental Protection Council, 1994). On December 30, 1994, government Act 490 formalized the establishment of the Environmental Protection Agency (EPA) as the primary government agency responsible for the formulation and enforcement of policies related to all aspects of the environment (Environmental Protection Agency Act, 1994). The Ghana Poverty Reduction Strategy: 2003–2005 International Monetary Fund, 2003) points out that the country is implementing a number of activities related to natural resource and environmental management. District assemblies have over the years been collaborating with departments such as the EPA, Ghana Education Service, Forestry Commission and other NGOs in the development and implementation of their Medium Term Development Plans.

2.4.1 Issuance of Environmental Permit to Sand and Stone Mining Firms

According to section 30 (1) of the Environmental Assessment Regulations (1999), environmental permit means an environmental authorization to commence a proposed undertaking or continue with the undertaking, issued after registration of the undertaking or upon submission of a preliminary environmental report or environmental impact statement. Clause 2 subsection 7 of the same regulation which deals with sand and stone quarries states that a stone mining firm requires a permit when the total area to be mined is greater than ten (10) hectares or where any portion of the stone quarrying operation is to be located within an environmentally portioned area. On sand and gravel pits, a permit is required when the area is greater than ten (10) hectares or where any portion of the sand or gravel mine is to be located within an environmentally sensitive area (Environmental Assessment Regulations, 1999). Environmentally Sensitive Areas as defined by the Environmental Assessment Regulations, (1999) includes;

1. All areas declared by law as national parks, watershed reserves, wildlife reserves and sanctuaries including sacred groves.
2. Areas with potential tourist value.
3. Areas which constitute the habitat of any endangered or threatened species of indigenous wildlife (flora and fauna).
4. Areas of unique historic, archaeological or scientific interests.
5. Areas which are traditionally occupied by cultural communities.
6. Areas prone to natural disasters (geological hazards, floods, rainstorms, earthquakes, landslides, volcanic activity etc.)
7. Areas prone to bushfires.
8. Hilly areas with critical slopes.
9. Areas classified as prime agricultural lands.
10. Recharge areas of aquifers.
11. Water bodies characterized by one or any combination of the following conditions

a) Water tapped for domestic purposes;

b) Water within the controlled and/or protected areas;

c) Water which support wildlife and fishery activities.

12. Mangrove areas characterised by one or any combination of the following conditions

    a) Areas with primary pristine and dense growth;

    b) Areas adjoining mouth of major river system;

    c) Areas near or adjacent to traditional fishing grounds;

    d) Areas which act as natural buffers against shore erosion, strong winds or storm floods.

The Environmental protection Agency may suspend, cancel or revoke an environmental permit or certificate issued under the Environmental Assessment Regulations where the holder of the permit or certificate;

a) Fails to obtain any other authorization required by law in relation to his undertaking before commencement of operations;

b) Is in breach of any provision of these Regulations or any other enactment relating to environmental assessment;

c) Fails to make any payments required under these Regulations on the due date

d) Acts in breach of any of the conditions to which his permit or certificate is subject; or

e) Fails to comply with mitigation commitments in his assessment report or environmental management plan (Environmental Assessment Regulations, 1999).

Under section 26 (2) of the Environmental Assessment Regulations, The Agency may also suspend an environmental permit or certificate in the event of occurrence of fundamental change in the environment due to natural causes before or during the implementation of the undertaking;

and upon such change the environmental assessment report and the environmental management plan shall be revised on the basis of the new environmental condition (Environmental Assessment Regulations, 1999).

2.4.2 Environmental Impact Assessment

Environmental impact assessment is the process for the orderly and systematic evaluation of a proposal including its alternatives and objectives and its effect on the environment including the mitigation and management of those effects; the process extends from the initial concept of the proposal through implementation to completion, and where appropriate, decommissioning; (Environmental Assessment Regulations, 1999). It is mandatory according to regulation 3 section 11 of the Environment Assessment Regulations (1999), for environmental impact assessment to carried out when the proposed quarrying of aggregate, limestone, silica, quartzite, sandstone, marble and decorative building stone lies within 3 kilometres radius of any existing village, residential, commercial or industrial areas, or any area earmarked for residential, commercial or industrial development. Environmental impact assessment is also mandatory in sand dredging operations.

2.4.3 Environmental Management Plan

Section 24 (1) of the Environmental Assessment Regulations (1999), states that the person responsible for an undertaking in respect of which a preliminary environmental report or an environmental impact statement has been approved shall submit to the Agency an environmental management plan in respect of his operations within 18 months of commencement of operations and thereafter every 3 years.

Clause 2 of the same section states that a person engaged in any of the undertakings mentioned in Schedule 1 which was in existence before the coming into force of these Regulations shall also submit an environmental management plan within 18 months from the coming into force of these Regulations and thereafter every 3 years (Environmental Assessment Regulations, 1999).

According to 24 (3) the environmental management plan shall be a document in such form as shall be determined by the Agency.

Section 24 (4) notes that the environmental management plan shall set out steps that are intended to be taken to manage any significant environmental impact that may result from the operation of the undertaking.

2.4.4 The Environmental Protection Agency Act (Act 490)

Environmental Protection Laws in Ghana date back to Ghana's colonial era. The laws, then, were mostly related to disease prevention and control. And they were often enforced in the bigger towns where government officers and factories were located. For example, one of the earliest laws on our statute books is the Beaches Obstruction Ordinance (Cap 240) of 29th January 1897. After independence, several laws were passed to help the young nation develop its industrial capability. Environmental Protection, however, became topical in Ghana after the 1972Stockholm Convention. This led to the establishment of the EPC in 1974. It was later transformed to the Environmental Protection Agency in 1994. (Environmental Protection Agency – Ghana, 2011)

The 1992 constitution of the 4th Republic in chapter six specifically article 41 (k) enjoins the citizens of Ghana to protect and safeguard the environment. This is for both employers and employees of Ghana. It is therefore not out of place that parliament passed the Environmental Protection Agency Act 1994.

The Act which is in three parts established the Agency and listed its functions;

a) To advise the Minister on the formulation of policies on the environment and in particular to make recommendations for the protection of the environment;

b) To co-ordinate the activities of bodies concerned with the technical or practical aspects of the environment and serve as a channel of communication between those bodies and the Ministry;

c) To co-ordinate the activities of the relevant bodies for the purposes of con-trolling the generation, treatment, storage, transportation and disposal of industrial waste;

d) To secure by itself or in collaboration with any other person or body the control and prevention of discharge of waste into the environment and the protection and improvement of the quality of the environment;

e) To collaborate or co-ordinate with foreign and international agencies for the purposes of this Act;

f) To issue environmental permits and pollution abatement notices for controlling the volume, types, constituents and effects of waste discharges, emissions, deposits or any other source of pollutants and of substances which are hazardous or potentially dangerous to the quality of the environment or a segment of the environment;

g) To issue notice in the form of directives, procedures or warnings to any other person or body for the purpose of controlling the volume, intensity and quality of noise in the environment;

h) To prescribe standards and guidelines relating to the pollution of air, water, land and any other forms of environmental pollution including the discharge of waste and the control of toxic substances;

i) To ensure compliance with the laid down environmental impact assessment procedures in the planning and execution of development projects, including compliance in respect of existing projects;

j) To act in liaison and co-operation with government agencies, District Assemblies and any other bodies and institutions to control pollution and generally protect the environment;

k) To conduct investigations into environmental issues and advise the Minister on these issues;

l) To promote studies, research, surveys and analyses for the improvement and protection of the environment and the maintenance of sound ecological systems in the Republic;

m) To initiate and pursue formal and non-formal education programmes for the creation of public awareness of the environment and its importance to the economic and social life of the country;

n) To promote effective planning in the management of the environment;

o) To develop a comprehensive database on the environment and environmental protection for the information of the public;

p) To conduct seminars and training programmes and gather and publish reports and information relating to the environment;

q) to impose and collect environmental protection levies in accordance with this Act and the Regulations;

r) To regulate the import, export, manufacture, distribution, sale and use of pesticides; and

s) To perform any other functions conferred on it under this Act or any other enactment (Environmental Protection Agency – Ghana, 1994).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The aim of this chapter is to explain how the data for the research was approached, collected and analyzed to achieve the aim and objectives of the study. There are two types of analysis; the qualitative and the quantitative analyses. The quantitative analysis deals with quantitative material usually processed by the computer with their results analyzed in terms of percentages and absolute numbers whilst in qualitative analysis, the researcher examines all responses collected and compare his findings with other existing theories or information (Twumasi, 2001).

3.2 RESEARCH DESIGN

A research design is the arrangement of conditions for the collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure (Mouton and Marais, 1990). From this definition it is evident that the aim of a research design is to align the pursuit of a research goal with the practical considerations and limitations of the project. A research design thus implies that research is planned. It further implies decisions are taken before embarking on the study with the purpose of ensuring that potential mistakes are eliminated, thereby maintaining the lowest possible cost.

The first stage involved studying and understanding of the topic and identifying scope and objective of research topic that was proposed by the researcher. This study also employed the survey method by using questionnaires and Interviews. The questionnaires were administered by the researcher to the construction aggregates mine operators, the residents of the study area and the general public to elicit their views on the issues identified in the research objectives.

3.3 LOCATION OF AGGREGATE MINES

The study showed that active construction stone quarries are concentrated near the Accra Metropolis and surrounding Municipal and District capitals where most homes, office construction and major road construction works occur (e.g. Foso Stone Quarry and mining services Ltd located at Accra – north , Ishaque Enterprise at Amasaman and Nii Tettey Okpe and Famil. at Pokuasi). Sand and gravel mines are, however, scattered within the study region, but the largest of these mines are also near the Accra Metropolis and other urban areas within the region of which Amasaman is not an exception. The results agree with the view of Blodgett (2004) that economics of construction materials depend heavily on the proximity of the sources of aggregates to the point of use since haul costs, including fuel, labour, and maintenance, are the single largest variable in determining the cost of aggregate materials.

3.4 POPULATION AND SAMPLE

White (2004) defines population as the sum total of all the objects, events or individuals that have common characteristics. Pretorius, (1995) also defines a population as the "total collection of individuals or objects that forms the focus of the research" whereas the sample is "a selected part or a subset of the population. According to Pretorius (1995) also, research is generally conducted to make inferences about the population based on the information available about the sample, in order to make inferences from the sample to the population. The population of this research was taken as all construction aggregates miners within the Greater Accra region (the minerals commission), nearby residents within the locality of Amasaman which lies within the Ga West Municipal Assembly of the Greater Accra Region.

3.5 SAMPLING TECHNIQUE

The sample size of 75 constructions aggregate mining companies was chosen for the study based on the Kish Formula; Illustrated in the next section. The names of 207construction aggregate miners in the study area were written on a piece of paper and placed in a box. There was a shuffle such that each name stood an equal chance of being selected for the research study. The 75 constructions aggregate mining companies included in this study were then chosen at random, one after the other till the 75th constructions aggregate mining company was selected. For the residents near the constructions aggregate mining sites 190, questionnaires were sent out also based on the Kish formula. This means that a random sampling was conducted. This random sampling method was used as it eliminates all bias in the collection of data. It further eliminates the prejudice of judging the results even before the research has been conducted or concluded.

3.6 SAMPLE SIZE DETERMINATION FOR THE RESIDENTS.

In order to obtain a sample that is representative of the population, the Kish Formula was used in determining the sample size. Statistics contained in the 2000 Population and Housing Census obtained from the Ghana Statistical Service indicates that as at the year 2000 there were 626 housing units in Amasaman which is the capital of the Ga West Municipal Assembly. Since the 2000 Population and Housing Census is the most recent population census, the figure 626 from the census was used as the total population of houses in the area.

The Kish Formula states;

$$\boldsymbol{n} = \frac{n^1}{(1 + n^1/N)}$$

Where,

$\boldsymbol{n}$ = Sample size

N = Total number of houses in the locality

$\boldsymbol{n^1}$ **=** S^2/V^2

V = the standard error of sampling distribution = 0.05

$\mathbf{S^2}$ = the maximum standard deviation of the population

Total error = 0.1 at confidence interval of 95%

$\mathbf{S^2}$ = P (1 – P)   where P = 0.5

= 0.5 (1 – 0.5)

= 0.25

P = the proportion of the population elements that belong to the defined region.

Since $n^1 = S^2 / V^2$

$= 0.25 / 0.05^2$

$n^1 = 100$

N = 626

$$\boldsymbol{n} = \frac{100}{(1 + 100/626)}$$

$$\boldsymbol{n} = \frac{100}{1.15974}$$

$n = 86.23$

~ 86

Adding 10% for non responsiveness;

$\frac{10}{100} \times 86 = 8.6 \sim 9$

Sample size = 86 + 9 = 95

Therefore 190 questionnaires were administered to 95 different households. (2 questionnaires per household, half the average household size for Amasaman)

3.7 SAMPLE SIZE DETERMINATION FOR THE CONSTRUCTION AGGREGATE MINING COMPANIES

Data collected from the minerals commission indicate that there are a total of 207 registered construction aggregate mining companies within the Greater Accra region which was used in the determination of the number of constructions aggregate mining companies that the questionnaires were administered to.

As stated previously, The Kish Formula states;

$$\boldsymbol{n} = \frac{n^1}{(1 + n^1/N)}$$

Where,

$\boldsymbol{n}$ = Sample size

N = Total number of houses in the locality

$n^1 = S^2/V^2$

V = the standard error of sampling distribution = 0.05

S^2 = the maximum standard deviation of the population

Total error = 0.1 at confidence interval of 95%

$S^2 = P\,(1 - P)$ where P = 0.5

$= 0.5\,(1 - 0.5)$

$= 0.25$

P = the proportion of the population elements that belong to the defined region.

Since $n^1 = S^2 / V^2$

$= 0.25 / 0.05^2$

$n^1 = 100$

N = 207

$$n = \frac{100}{(1 + 100/207)}$$

$$n = \frac{100}{1.483092}$$

$$n = 67.5267$$

~ 68

Adding 10% for non responsiveness;

$\frac{10}{100} \times 68 = 6.8 \sim 7$

Sample size = 68 + 7 = 75

Therefore 75 questionnaires were administered to 75 different construction aggregate mining companies.

3.8 QUESTIONNAIRE DESIGN

In constructing a questionnaire, the field problems must be outlined and the objectives specified. Each objective should give the researcher a clear focus in order to formulate relevant questions. They must be clearly stated and functionally specific. The language must be clear; ambiguity must be avoided. The questions must be framed in a socially – acceptable way" (Twumasi, 2001). Some of the questions however involved ranking of responses using the Likert Scale. This was achievable using close ended questions (Froddy, 1993).

3.9 TYPES OF QUESTIONS

Twumasi, (2001) gives the two types of question formats used in a questionnaire as a pre – coded format and an open – ended form. In a pre – coded form of questionnaire construction, the researcher sets questions and at the same time, he provides all possible answers he expects to obtain from the respondents. When this happens, it is easy for the respondents to respond to the appropriate answer. In the open – ended form however, the questions are framed as specific questions with no possible answers provided. The researcher in this case expects the respondents to provide their own answers. In this research, although the two forms of questions were used, the pre – coded format was made use of more than the open – ended format since quantitative analysis would be the main form of analysis proposed for the project. They were also mostly used to make their answering easier for the respondents.

3.10 QUESTIONNAIRE ADMINISTRATION

Self-administered questionnaire were used because of the ease of gathering information quickly from people and in a short period of time and without intimidating the respondents. Some of the advantages of using self-administered questionnaires proposed by Twumasi (2001), include; the efficiency in collecting statistically quantifiable information; it is an efficient method in the sense that many respondents can be reached within a short space of time. The respondents consist of the mine operators, sand and stone contractors (together referred to as "miners"), residents near mining sites or the general public and the regulatory authorities such as the Environmental protection agency.

3.11 DATA COLLECTION PROCEDURE

The questionnaires were circulated to three categories of respondents: the mine operators, including sand and stone contractors (together referred to as "miners"), residents near mining sites or the general public and the regulatory authorities such as the Environmental protection agency.

3.12 DATA ANALYSIS

The information collected from the study was checked for accuracy. The results were then analyzed using descriptive statistics and mean score statistical techniques. Descriptive statistics is a powerful statistical tool that describes the main features of the data collected quantitatively. They provide simple summaries about samples and measures in the form of percentages, graphics, central tendencies (mean, median, mode, maximum, minimum and standard deviation), and frequency distributions (Trochim, 2006). On one of the questions, the respondents were asked to express their views on issues concerning the impact of aggregate mining activities on the environment on a five-point Likert scale (from 1 = 'not severe', 2 = 'somewhat severe', 3 = 'severe', 4 = 'very severe' to 5 = 'extremely severe')

The mean score of each variable was calculated using the formula: MS = $\left[\frac{\Sigma(f \times s)}{N}\right]$ Where **MS** is the mean score, ***f*** *is* the frequency of the responses to each rating (1 – 5), ***s*** is the score given to each variable by the respondents (ranges from 1 to 5) and ***N*** is the total number of responses concerning that factor. SPSS (Statistical Package for the Social Sciences) software was the computer software used in the analysis. SPSS provides a broad range of capabilities for the entire analytical process.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter gives the results of the data collected from the questionnaires which were administered and how it was discussed and analysed. The descriptive style of statistics was used in the analysis of data being represented with diagrams, charts and tables.

4.2 RESPONSE RATE

A total of 75 questionnaires were administered to the miners/construction aggregate mining firms of which 46 were retrieved giving a response rate of 61%. Most of the questionnaires which were administered during the study took a couple of days to be filled and retrieved. For residents nearby to the construction aggregate mining sites, a total of 190 questionnaires were administered of which 132 were retrieved giving a response rate of 69%. The Environmental Protection Agency received and returned a questionnaire which implied a 100% response. The response rate of each category of respondents with respect to the questionnaires sent out and retrieved were tabulated and presented in table 4.1 to make analyzing the data simpler.

Table 4.1 Response Rates to the Questionnaires

Respondents	Questionnaires Sent Out	Questionnaires Received	Percentage Responsive
Miners/ Construction Firms	75	46	61%

Nearby Residents/ General Public	190	132	69%
Environmental Protection Agency	1	1	100%

4.3 DATA DISCUSSION

The results obtained from the data collected were discussed under each specific set of questionnaire as follows;

4.3.1 Respondents' Profile

Mine operators and construction aggregate mining firms who responded to the questionnaire have been in business for at least 5 years. Majority (43.5%) of these firms or miners have been in operation between 16 to 20 years whilst the least number of years a mining firm has been in operation was given as between 0 to 5 years (15.2%). Responding residents near mining sites also agreed to the miner's view whereby majority (37.9%) stated that the mine sites has been in operation for 11 to 15 years. The various years of the mine sites being in operation given by the miners and residents are presented in table 4.2

Table 4.2 Number of years the mine has been on operation

Miners/ Aggregate mining Firms		Nearby Residents	
0 – 5	15.2%	0 – 5	9.1%
6 – 10	19.6%	6 – 10	30.3%
11 – 15	21.7%	11 – 15	37.9%
16 – 20	43.5%	16 – 20	22.7%

4.3.2 Size and Scope of Aggregate Mining Operations

The mine operators were asked to state the size and scope of their operations. The results revealed a wide variability in the size and scope of aggregate mining operations, from small (covering about 0.5 hectares) to large (covering about 5 hectares and above). Whilst some mines are active only for a project's duration (e.g. for road construction), others operate continuously for several years (e.g. general construction) until the material deposit become exhausted. Most of the mines surveyed have been in operation for more than twenty years (e.g. stone quarries). Some mine operators indicated during face-to-face interviews that operations could continue as long as there is market for construction aggregates, and until the original land owners take back their lands. This indicates that as long as the construction industry demands natural aggregates, mining operations will continue to impact the physical environment; and such impacts will assume huge environmental significance with the rapid growth in population and the attendant implications for construction of infrastructure (Chrisna du Plessis, 2002). The various areas (in hectares) covered by the mines visited are given in the figure

4.1

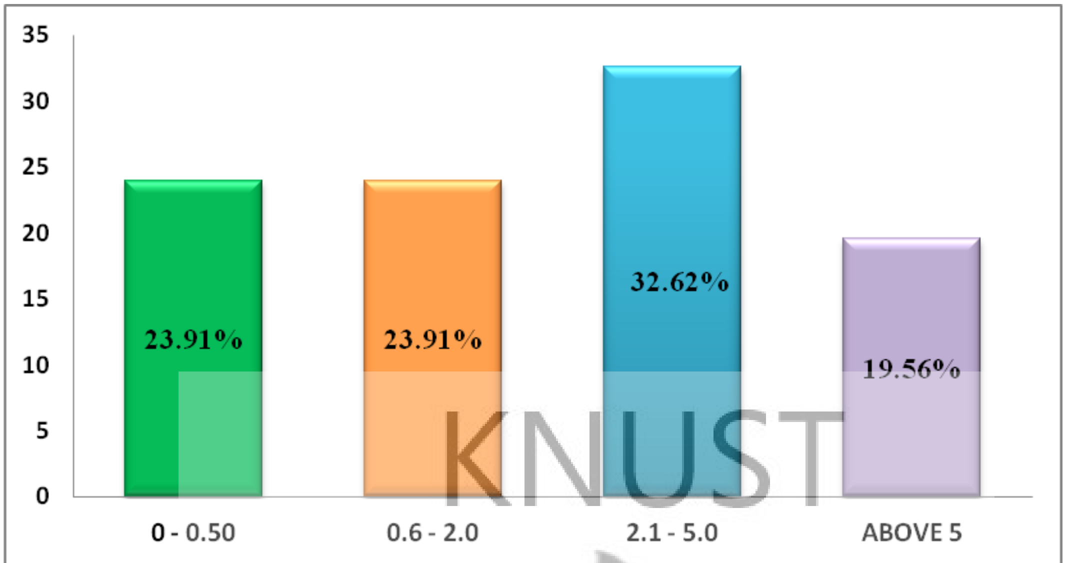

Figure 4.1 Sizes of Aggregate Mining Operations (in Hectares)

4.3.3 Types of Aggregates Mined

Respondents were asked to identify the types of aggregates they extract and the extraction methods they use. It was revealed that materials extracted and extraction methods differ from operation to operation. The study showed that aggregate mining in Ghana mainly involves three materials: unconsolidated sand, gravels and crushed stones. Out of the total of about 46 construction aggregate mining sites from whom questionnaires were retrieved, 15 representing 32.6% are in stone quarrying operations and 31 representing 67.4% are in sand and gravel mining operations. The study showed that some mining operations occur within the groundwater table (e.g. sand) and others remain above the water table (e.g. gravels and crushed rock). Various types of auxiliary facilities are used in aggregate mining operations in Ghana including crushers, screen plants, wash plants, and mechanical vibrators.

4.3.4 Current Uses of Aggregate Materials

The study showed that construction aggregate mining produces materials that are used mostly for building construction (100%) and road construction (84.8%) as well as other general uses in construction (Table 4.3). Quarry stones, sand and gravels are used for road construction as aggregates, base coarse, crushed rock etc. Aggregate materials are also used for building construction and landscaping as aggregates, fill, top soil, dimension stones etc. The results agree with what are reported from other studies. Blodgett (2004) mentioned uses of aggregate materials in road and building construction (e.g. sand, gravels, base course, crushed rock etc.), landscaping (e.g. topsoil, fill, dimension stone etc.), and other general construction uses. In another studies, West and Cho (2006), Blodgett (2004) and Woods (1960) stated that aggregates are necessary ingredients for highway pavements and structural concrete, accounting for 30% of the cost, and comprising by volume 65 to 85% of concrete and 92 to 96% of asphaltic pavements.

Table 4.3 Current uses of aggregate materials

Miners/ Aggregate mining Firms		**Ranking**
Building Construction	100%	**1**
Road Construction	84.8%	**2**
Land Filling	80.4%	**3**
Landscaping	54.3%	**4**
Other General Construction	26.1%	**5**

4.3.5 Aggregate Mining Activities Adversely Affecting the Environment

The research sought to find out which aggregate mining activities have adverse impact on the environment to enable mitigating measures to be found. Construction Aggregates miners/ mining firms and the residents living near these sites/the general public respondents identified the same seven Construction Aggregate mining activities that have significantly severe environmental impact. These are Clearance, Blasting, Earthmoving, Excavation, Crushing, Screening and Transportation (Table 4.4). In a descending order of severity, the respondents identified, Vibration from blasting, Transportation, Excavation, Crushing, Site clearance, Earthmoving and Screening to have significantly severe effects on the environment (Table 4.4). All the activities identified, give rise to atmospheric pollution. They results in degraded air quality from particulate and stack emissions which ultimately have serious health consequences (Blodgett, 2004; Ofori et al., 1999). Site clearance, earthmoving and excavation also cause degradation of land and destruction of the ecosystem (Blodgett, 2004; Ofori et al., 1999; UNCHS, 1993). Blasting also causes vibration which result in cracks in surrounding buildings.

Table 4.4 Aggregate mining activities that adversely impact the environment

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Blasting	84.8%	Blasting	79.5%
2	Transportation	65.2%	Transportation	74.2%
3	Excavation	50.0%	Clearance	56.1%
4	Crushing	41.3%	Crushing	50.0%
5	Clearance	26.1%	Excavation	50.0%
6	Earthmoving	21.7%	Earthmoving	40.2%
7	Screening	10.9%	Screening	5.3%

4.3.6 Primary Environmental Impacts from Construction Aggregate mining

While aggregate miners ranked Disturbed ground areas (78.3%) as the most severe primary environmental impact associated with construction aggregate mining activities, the residents identified Degraded air quality from stack emissions (71.2%) as the most severe. Disturbed ground areas and Impairment of surface and ground water quality were also identified as significantly severe primary environmental impacts from aggregate mining operations by both construction aggregates miners and the residents (Tables 4.5).

Table 4.5 Primary environmental impacts from construction aggregate mining activities

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Disturbed ground areas	78.3%	Degraded air quality from stack emissions	71.2%
2	Degraded air quality from stack emissions	60.9%	Disturbed ground areas	56.8%
3	Impairment of surface and ground water quality	32.6%	Impairment of surface and ground water quality	40.2%
4	Increased traffic on roads	17.9%	Increased traffic on roads	28.0%
5	Use of scarce water	10.9%	Use of scarce water	3.0%

Increased road traffic and use of scarce water were not considered to have significantly severe primary environmental impacts (Tables 4.5) as they were identified as the fourth and fifth primary impacts respectively. According to Blodgett (2004) the most obvious environmental impact from aggregates mines is degraded air quality, and associated health effects resulting from airborne emissions from both the stack and disturbed areas at the mines. Sediment loadings from aggregate mines to surface and ground water have also been identified as a source of significant degradation to water supplies (Blodgett, 2004). West and Cho (2006) stated that storm water runoff from aggregate mines to surface and groundwater requires that a water quality permit be obtained from the Environmental Protection Agency. According to Mason and Welgoss (2002), environmental problems from mining can be manifested as air, water, and noise pollution.

4.3.7 Potential Cumulative Impacts from Construction Aggregate Mining

Respondents were asked to identify potential cumulative impacts from the development of typical aggregate mines. The results show that aggregate miners and the general public consider dust and diesel fumes, fugitive dust blowing from uncovered dump trucks, dust from poorly monitored crushers, and from piles of crushed rock at construction aggregate mining sites, and increased traffic as the five significantly severe potential cumulative impacts from a stone quarry (Table 4.6). Increased population is not considered a significantly severe cumulative impact.

Table 4.6 Potential cumulative impacts from stone quarrying activities

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Excessive noise from blasting of rock using dynamites	63.0%	Excessive noise from blasting of rock using dynamites	81.8%
2	Dust and diesel fumes generated on haul roads to and fro the quarry site	45.7%	Visible deep cracks in walls of surrounding buildings arising from vibration	71.2%
3	Fugitive dust of larger particles blowing from uncovered or partially covered dump trucks	45.7%	Dust and diesel fumes generated on haul roads to and fro the quarry site	58.3%
4	Visible deep cracks in walls of surrounding buildings arising from vibration	43.5%	Fugitive dust of larger particles blowing from uncovered or partially covered dump trucks	50.0%
5	Fugitive dust from piles of crushed stones at the mines	39.1%	Fugitive dust or larger particles from poorly monitored crushers and out – of - compliance operations	46.2%

6	Fugitive dust or larger particles from poorly monitored crushers and out – of - compliance operations	39.1%	Fugitive dust from piles of crushed stones at the mines	33.3%
7	Increased traffic with a concomitant increase in air pollution from vehicles	37.0%	Increased traffic with a concomitant increase in air pollution from vehicles	29.5%
8	Increased air pollution from abandoned mines and until natural re – vegetation stabilizes the surface soil	21.7%	Increased air pollution from abandoned mines and until natural re – vegetation stabilizes the surface soil	16.7%

Sand and gravel miners and the residents also identified dust and diesel fumes generated on haul roads to and from the mines, fugitive dust blowing from uncovered dump and increased traffic as three significantly severe potential cumulative impacts (Table 4.7). Increased population and increased air pollution from some construction aggregates mines after they are abandoned until natural re – vegetation stabilizes the surface soil are, however, not considered having significantly severe cumulative impacts.

Table 4.7 Potential cumulative impacts from sand and gravel mining activities

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Dust and diesel fumes generated on haul roads to and from the mines	45.7%	Fugitive dust blowing from uncovered or partially covered dump trucks	59.8%
2	Fugitive dust blowing from uncovered or partially covered dump trucks	43.5%	Dust and diesel fumes generated on haul roads to and from the mines	50.0%
3	Fugitive dust from poorly monitored crushes and out – of – compliance operations	39.1%	Increase traffic with a concomitant increase in air pollution from vehicles	44.7%
4	Increase traffic with a concomitant increase in air pollution from vehicles	37.0%	Fugitive dust from piles of construction aggregates at the mine	39.4%

5	Fugitive dust from piles of construction aggregates at the mine	19.6%	Fugitive dust from poorly monitored crushes and out – of – compliance operations	35.6%
6	Increased population with a concomitant increase in disturbed land areas	17.8%	Increased population with a concomitant increase in disturbed land areas	30.3%
7	Increased air pollution from some construction aggregates mines after they are abandoned until natural re – vegetation stabilizes the surface soil	10.9%	Increased air pollution from some construction aggregates mines after they are abandoned until natural re – vegetation stabilizes the surface soil	21.2%

The results confirm findings from other studies which report that the most obvious environmental impact from aggregate mining is degraded air quality from airborne emissions generated from both stack and the disturbed areas at the mines (Blodgett, 2004). West and Cho (2006) stated that aggregate mining facilities must meet minimum standards for dust. Also, crushing operations must meet standards for emissions of particulates from processing equipment.

Blodgett (2004) further stated that each of the impacts from construction aggregate mining identified above produces environmental effects that are difficult to measure, and the cumulative effect contribute to the overall degradation of the environment. Increased traffic on public roads creates hazards as trucks enter and leave public roads many times in a day. Blodgett (2004) stated that aggregate mines should be viewed as a first step in development, whether it is highway, residential, or general construction. When construction aggregate is conveyed from the point of excavation, through loading and hauling, and to its ultimate use as either fill, base course, or some other construction use, it becomes clear that the environmental impacts of construction aggregate mining will be widespread and cumulative.

4.1.1 Land Use Impacts from Construction Aggregate Mining

On the land use impacts arising from construction aggregate mining, respondents in the two categories identified three significantly severe impacts on which both categories of respondents agree on including erosion of exposed areas, loss of wildlife habitat, and Loss of native plant life (flora) (Table 4.8). They do not, however, consider construction aggregate mining to have significantly severe impact on Loss of aquatic biota and the loss of birds and terrestrial fauna.

Site clearance and excavation are site activities which have been found to result in the loss of wildlife and native plant habitat (Teixeira, 2005; Uher, 1999; U.S. Environmental Protection Agency, n.d.). The use of heavy machinery and transportation of materials disturb the ground and result in erosion of exposed areas (Teixeira, 2005; U.S. Environmental Protection Agency, n.d.). Site clearance also leads to soil erosion and sedimentation associated with the movement of heavy machinery. Exposing the soil through site clearance can also lead to contamination of the soil with chemical and other harmful products used at the mine. Environmental impacts such as noise arising out of mining activities like blasting, crushing, screening, hauling etc., and human presence can result in the loss of wildlife, birds and terrestrial fauna. The removal of the superficial soil layer results in the loss or damage to tree roots and ultimately destruction of the ecosystem (Teixeira, 2005; Uher, 1999). Sediment loadings from aggregate mines to surface and ground water have been identified as a source of significant degradation to water supplies (Blodgett, 2004, Mason and Welgoss, 2002; Cole, 2000). West and Cho (2006) stated that penetration of contaminants into aquifer systems are possible consequences of aggregate mining operations. Blodgett (2004) stated that although aggregate mining results in surface and groundwater degradation, they do not generate acidic runoff containing heavy metals to cause poisoning or cancer.

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Table 4.8 Land use impacts from construction aggregate mining

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Erosion of exposed and excavated areas	52.2%	Erosion of exposed and excavated areas	66.7%
2	Loss of wildlife	43.5%	Loss of wildlife	56.1%
3	Loss of native plant life (flora)	43.5%	Loss of native plant life (flora)	50.0%
4	Contamination of surface and groundwater	37.0%	Sedimentation associated with use of heavy machinery	46.2%
5	Sedimentation associated with use of heavy machinery	34.5%	Contamination of soils	42.4%
6	Loss of in – stream habitat	30.4%	Contamination of surface and groundwater	40.2%
7	Contamination of soils	26.1%	Loss of terrestrial and aquatic vegetation	35.6%
8	Loss of terrestrial and aquatic vegetation	17.8%	Loss of birds and terrestrial fauna	30.3%
9	Loss of birds and terrestrial fauna	15.2%	Loss of in – stream habitat	20.5%
10	Loss of aquatic biota	15.2%	Loss of aquatic biota	15.2%

4.3.9 Nuisance Effects from Construction Aggregate mining

In order to assess whether construction aggregate mining operations cause “public nuisance”, respondents were asked to identify those impacts that create public nuisance.

Respondents from the two categories identified the same three environmental impacts from construction aggregate mining operations that create significantly severe public nuisance as noise, vibration and dust (Tables 4.9). Vehicular traffic was also identified by construction aggregates miners and the residents to cause public nuisance.

Table 4.9 Nuisance effects from construction aggregate mining

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Vibration from blasting	76.1%	Dust causing impaired vision, aesthetic degradation and dusty cover	81.1%
2	Noise	50.0%	Noise	67.4%
3	Dust causing impaired vision, aesthetic degradation and dusty cover	45.7%	Vibration from blasting	60.6%
4	Traffic congestion and safety hazards	30.4%	Traffic congestion and safety hazards	50.0%
5	Bright lights at night	30.4%	Increase in population	40.2%
6	Increase in population	21.7%	Bright lights at night	30.3%
7	Road blocks and diversions	21.7%	Road blocks and diversions	26.5%

The results obtained confirm those from other studies. West and Cho (2006) asserted that aggregate mining can inflict a significant nuisance effect on the neighbouring community. According to Mason and Welgoss (2002), environmental problems from mining can be manifested as air, water, and noise pollution. Loud noise from blasting, crushers, screen plants and vehicle horns has been identified to create public nuisance effects (Teixeira, 2005; Blodgett, 2004; Cole, 2000; Choi, 1997). Chronic dust emissions from crushers and hauling trucks, and vibrations from blasts disturb nearby residents and mine workers (Teixeira, 2005; Blodgett, 2004; Cole, 2000; Choi, 1997). Nearby homes can be covered with a fine layer of dust from the mines which will require constant cleaning (Teixeira, 2005). Teixeira (2005) stated that increase in local vehicular traffic resulting from aggregate mining may be a source of significant nuisance to the neighbouring community.

4.3.10 Level of the Disturbance in the Case of Construction Aggregate mining Activities

The respondents were asked to express their views on the level of disturbance from construction aggregate mining activities on the environment on a five-point Likert scale (from 1 = 'not severe', 2 = 'somewhat severe', 3 = 'severe', 4 = 'very severe' to 5 = 'extremely severe'). Mean score above 2 implies that the factor under consideration has severe environmental impact. The factors were ranked according to the mean scores **(MS)** calculated using the Statistical Package for the Social Sciences (SPSS). In the analysis, a factor with a higher mean was ranked higher than another with a lower mean. In cases where two factors have the same mean, the standard deviation was used where in this case a factor with a lower standard deviation was ranked higher as it deviates little from the mean. Table 4.10 illustrates the ranking of the factors.

Table 4.10 Level of disturbance from construction aggregate mining operations

Rank	Miners/ Aggregate mining Firms	N	Mean	Standard Deviation	Nearby Residents	N	Mean	Standard Deviation
1	Dust generation	46	3.33	1.461	Noise generation	132	3.58	1.387

2	Noise generation	46	3.98	1.273	Dust generation	132	3.91	1.251
3	Construction traffic	46	3.22	1.428	Construction traffic	132	2.98	1.444

As can be seen from Table 4.10, Dust generation has been ranked by both residents near mining sites and the miners as the factor that contributes more disturbances at construction aggregate mining sites. This is followed by Noise generation and Construction traffic. It can also be observed from the table that all the factors had a mean of above 2 and are therefore considered as having severe environmental impacts on the environment. Loud noises from crushers and screen plants, and chronic dust emissions creates public nuisance for those people unfortunate enough to live near such operations (Blodgett, 2004).

4.3.11 Health Hazards Arising from Construction Aggregate mining

Respondents identified cold and catarrh, respiratory disorders, chronic irritation of the lungs and mucus membrane from gypsum dust, and asthma as the major health hazards arising from aggregate mining (Table 4.11). Cold and catarrh, respiratory disorder, and asthma, arise out of dust and fuel fumes from aggregate mining operations. Blodgett (2004) stated that the most recognized health hazards from aggregate mining involve air borne particulate emissions, posing the greatest respiratory health hazards. According to Blodgett (2004), none of the minerals contained in mined materials, however, is known to cause heavy-metals poisoning or cancer, and the potential health risks from the minerals involve respiratory problems caused by chronic irritation of the lungs and mucus membranes.

Table 4.11 Health hazards arising from construction aggregate mining

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Cold and catarrh	82.6%	Cold and catarrh	62.9%

2	Respiratory disorders from air-borne particulate emissions	76.1%	Respiratory disorders from air-borne particulate emissions	56.8%
3	Chronic irritation of the lungs and mucus membrane from gypsum dust	52.2%	Asthma	50.0%
4	Stress effects	34.8%	Sleeplessness	43.2%
5	Sleeplessness	30.4%	Stress effects	35.6%
6	Asthma	21.7%	Chronic irritation of the lungs and mucus membrane from gypsum dust	30.3%
7	Malaria from mosquitoes	19.6%	Silicosis from prolonged exposure to extreme fine particles of silica	25.0%
8	Allergies	17.4%	Malaria from mosquitoes	25.0%
9	Silicosis from prolonged exposure to extreme fine particles of silica	15.2%	Allergies	20.5%

4.3.12 People Likely to be Adversely Affected by Construction Aggregate Mining Activities

People most likely to be adversely affected by the impacts of aggregate mining operations were identified by the respondents as mine workers, nearby residents, and the general public (Table 4.12). The results show that from the perspective of the aggregates miners, the people living near construction aggregate mining sites and the site workers are likely to be affected in equal measure (73.9%). Whereas in the perspective the nearby residents, the people living near this aggregate mining sites are more likely to be affected than the site workers. (67.4% and 64% respectively). Both categories of respondents however agree that the general public is the least affected by construction aggregate mining activities. The above results explain why residents are worried and concerned about the impacts of aggregate mining operations in their neighborhood, given the close proximity of aggregate mines to communities. The results from the study agree with those reported in the literature. Blodgett (2004) and Cole (2000) stated that noise and vibrations are annoying and disruptive to nearby residents, site workers, and the general public. Excessive noise generated from mining sites affect the right to silence, comfort and health of workers and nearby residents (Teixeira, 2005; Blodgett, 2004; Choi, 1997). Public concerns over the environmental impact of aggregate mining must therefore be given serious attention.

Table 4.12 People likely to be affected by construction aggregate mining

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Site Workers	73.9%	People living near the aggregates sites	67.4%
2	People living near the aggregates sites	73.9%	Site workers	64.4%
3	The general public	26.1%	The general public	30.3%

4.3.13 Current Management Systems for Disused Aggregates Mines

Respondents were asked to indicate management systems for disused aggregate mines. The results show that although the miners ranked Left to natural re – vegetation as the least adopted method for the management of disused construction aggregates mine sites (15.2%), the residents living near such construction aggregates mine sites thought otherwise as in their opinion and experience such a method is rather the most adopted method (75.0%) for the management of such disused mine pits. Only little planned re-vegetation of degraded mining sites occur. No major reclamation programmes for degraded areas are done by aggregate mining operators (Tables 16 and 17). Currently degraded mining areas are mainly used as landfills sites, refuse dumps, or are left for natural regeneration (Tables 4.13).

Although construction aggregate mine pits have been utilized in the past to dispose of solid and industrial wastes and thereby re-establish the former land surface, regulations and environmental concerns in recent years prevent the placement of solid waste in unlined pits and quarries (West and Cho, 2006). The authors mention contamination as one result of this practice. Barksdale

(1991) suggested that reclamation plans must be approved before aggregate extraction can begin. Although aggregate mines sited close to communities and road construction projects make construction less expensive, the impacts of hundreds of abandoned pits and active aggregate mines on the scenic environment are significant, and constitute aesthetic degradation.

Table 4.13 Management systems for disused stone quarry sites

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Landfill	65.2%	Left to natural re – vegetation	75.0%
2	Reclamation	47.8%	Refuse dump	65.9%
3	Planned re – vegetation	32.6%	Landfill	57.6%
4	Refuse dump	26.1%	Reclamation	27.3%
5	Left to natural re – vegetation	15.2%	Planned re – vegetation	12.1%

4.4 THE EPA AND CONSTRUCTION AGGREGATE MINING.

In order to get a fair idea of the monitoring role of the Environmental Protection Agency (EPA), certain questions were included in this research and after analyzing those questions the following results were got.

4.4.1 Educational and Sensitization Programs

Residents were asked whether the EPA has been organizing educational and sensitization programmes for them and others on how to cope with the effects of construction aggregates activities. Out of the total of 132 questionnaires that were retrieved, 117 respondents representing 85% of the respondents indicated the absence of such educational and sensitization programs while 15 residents representing 10% of the respondents indicated the availability of such educational and sensitization programs. 18 residents (15%) however chose not to answer that particular question.

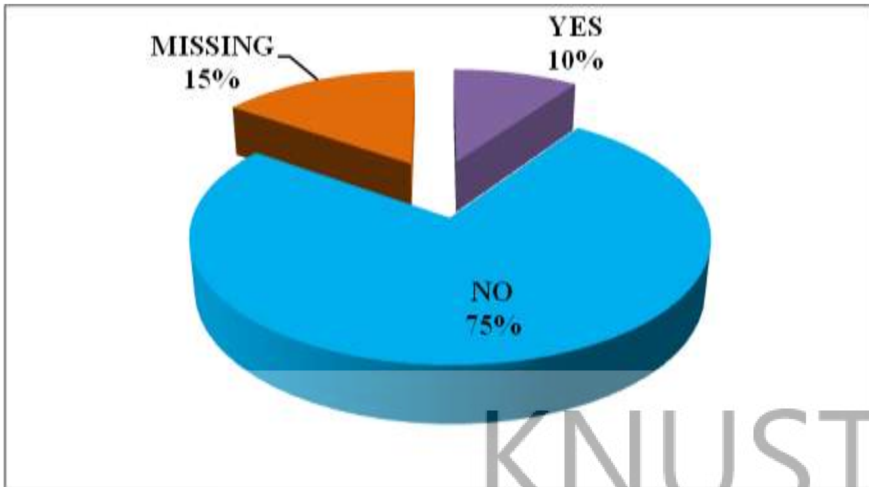

Figure 4.2 Organisation of Educational and sensitization programs.

4.4.2 Frequency of the Organisation of Educational and Sensitization Programs.

Out of the 15 that responded that those Educational and sensitization programs do exist, 73.33% said such educational and sensitization programs are organized yearly for them while 26.67% said such programs were organized monthly. No respondent however said the programs were organized weekly.

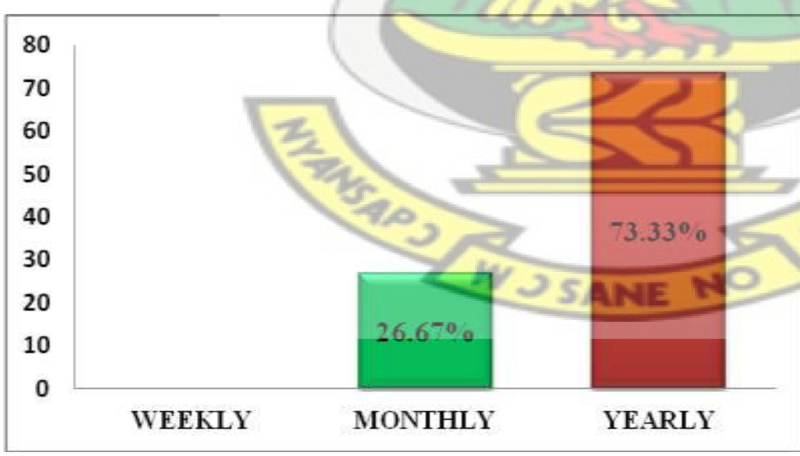

Figure 4.3 Frequency of organizing educational and sensitization programs

4.4.3 Mode of Educating the Residents

The results indicate that 11 residents representing 73.33% of the respondents said they receive such education and sensitization from the EPA through the mass media while 4 residents (26.67%) received such education through the newspapers. No resident however stated receiving such education through the public van. The information is presented in table 4. 14.

Table 4.14 Mode of Educating residents by the EPA

Ranking	Nearby Residents	Frequency	Percentage
1	Through the mass media	11	73.3%
2	Through the newspapers	4	26.7%
3	Through the public van	0	0.0%

4.4.4 Measures for Controlling Environmental Impacts from Aggregate mining

The people living near mining sites/general public suggested eleven significantly important measures to adopt to control environmental impacts from construction aggregate mining. These include enforcement of air quality permits, covering of dust generating materials, use of less air polluting equipment, and denying permits to mines on unsuitable lands (Tables 4.14). Mine operators also suggested the covering of dust generating materials, enforcement of laws on reclamation and dampening of dust generating materials during transport among eleven significantly important measures for controlling environmental impacts from construction aggregate mining (Tables 4.14). Air borne particulate emissions can be reduced if air quality permits are enforced in Ghana. These permits require that sampling is done at least once every 7 days for a 24-hour period. The measurements must be taken from a stack and must include emissions from pits, haul roads and disturbed areas on the site. Dust and diesel fumes arise from transportation of aggregate materials on haul roads. Dust also arises from pits and disturbed areas on the ground. Watering of haul roads and the mining areas, and covering of materials in transit and in stock piles can help minimize these impacts and reduce the health hazards. Refusal of permits to mines in environmentally sensitive sites such as "sacred sites," historic rural communities, protected wetlands, threatened or endangered species habitats, and in areas where the resulting "scar" will ruin a scenic view shed. Thus, the environmental impacts of aggregate mining can be mitigated by enforcing environmental regulations.

Table 4.15 Measures for controlling environmental impacts from construction aggregate mining activities

Ranking	Miners/ Aggregate mining Firms		Nearby Residents	
1	Cover dust generation materials	71.1%	Air quality or dust control permit checks and compliance should be enforced strictly and consistently	66.7%
2	Enforce laws on reclamation and re – vegetation of degraded mine areas	65.2%	Cover dust generation materials	56.1%
3	Provide water sprays to dampen dust generating material during transportation/storage	50.0%	Use properly maintained or less air polluting equipments	50.0%
4	Deny permits to mines proposed to be located in areas considered unsuitable	45.7%	Deny permits to mines proposed to be located in areas considered unsuitable	46.2%
5	Air quality or dust control permit checks and compliance should be enforced strictly and consistently	45.7%	Installation silt fencing or sediments basins to capture sediments	42.4%
6	Use properly maintained or less air polluting equipments	39.1%	Time scheduling of noisy operations	40.2%
7	Time scheduling of noisy operations	32.6%	Adopt noise abatement measure	35.6%
8	Adopt noise abatement measure	30.4%	Provide water sprays to dampen dust generating material during	30.3%

9	Encourage the use of re – cycled materials	30.4%	Encourage the use of re – cycled materials	20.5%
10	Installation silt fencing or sediments basins to capture sediments	21.7%	Enforce laws on reclamation and re – vegetation of degraded mine areas	15.2%
11	Deny operating permits if inactive or abandoned mines could be re – opened to provide the same resources	0.0%	Deny operating permits if inactive or abandoned mines could be re – opened to provide the same resources	0.0%

4.5 THE ENVIRONMENTAL PROTECTION AGENCY (EPA)

In order to give a better assessment of the impact of construction aggregate mining on the environment and the role of the Environmental Protection Agency in reducing or controlling the menace of construction aggregate mining activities, questionnaires were sent to the EPA for their response. The various responses given are discussed in the chapter.

4.5.1 Which ordinance/bye laws/legislations are in place for controlling excessive noise, smoke or dust levels from construction aggregate mining activities?

According to the EPA, it relies on the **EPA act 1994, act 490** and **district assembly bye – laws** to control the level of noise produced from construction aggregate mining in check.

4.5.2 Are these ordinance/bye laws/legislations for controlling excessive noise, smoke or dust levels from construction aggregate mining reviewed regularly?

According to the EPA these bye laws/legislations are not reviewed regularly

4.5.3 How often are these ordinance/bye laws/legislations for controlling excessive noise, smoke or dust levels from construction aggregate mining reviewed?

According to the EPA these bye laws/legislations are not reviewed regularly.

4.5.4 How effective have these ordinance/bye laws/legislations for controlling excessive noise, smoke or dust levels from construction aggregate mining been used?

The ordinance/bye laws/legislations for controlling excessive noise, smoke or dust levels from construction aggregate mining is usually used regularly and applies to all offenders who violate such bye laws.

4.5.5 What are other legislations enforceable by the EPA concerning construction aggregate mining?

Apart from the above laws the E. P. A. also utilizes the **L. I. 1652** of **1999** to regulate the effects of construction aggregate mining. The EPA also utilizes the assemblies' bye laws in the discharge of its duties.

4.5.9 What is the penalty for breach of the above legislations, if any?

Construction aggregate mining companies that were found defaulting legislations were penalized; these took the form of hefty fines, seizure of mining licenses and in extreme cases imprisonment.

4.5.10 Does the EPA carry out routine inspections/monitoring on construction aggregate mining sites?

According to the E. P. A. they made it a point to go on regular inspection during which construction aggregate mining companies found not conforming to the bye laws/regulations would be warned and penalized.

4.5.8 How often do you carry out such routine inspections/monitoring on constructions aggregate mining sites?

Monitoring activities are carried out very often at construction aggregate mining sites including small scale and illegal construction aggregate mining sites.

5.7.9 What triggers the inspections/monitoring on construction aggregate mining sites?

Inspections were normally carried out on certain factors some of which included persistent complaints from the public/nearby residents, E. P. A. officers passing by sites and noticing irregularities or sometimes planning occasional surprise visits. These were undertaken to make sure their rules and regulations were being kept.

5.7.10 Apart from the inspections/monitoring is there regular educational/sensitization programs carried out by the EPA for construction aggregates miners?

Educational/sensitization programs according to the EPA are carried out at regular intervals

5.7.11 How often are these educational/sensitization programs carried out if such programs do exist?

According to the EPA, these education and sensitising programs are organised at least once in a month.

5.7.12 Do you require that miners carry out Environmental Impact Assessment (EIA) before starting their operations?

The E. P. A. requires that companies undertaking any form of construction aggregate mining would carry out Environmental Impact Assessment (EIA) before operations which border on their standards (EPA) in order to minimize the effects their activities have on the environment.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The result has shown that aggregate mining operations in Ghana vary in size and scope from small to large. Whilst some mines become active only for a project's duration, others operate continuously for several years. The survey also showed that aggregate mining in Ghana mainly involves three materials: unconsolidated sand, gravels and crushed stones (Table 4.3). The mines produce materials that are used for building and road construction, and for other general uses in construction. Mining of construction aggregates yield significant effect on the environment and human life. The study has shown that adverse effects results from the mining of construction aggregates and these effects on the environment are self – evident and are on the rise. Also the individuals involved in the study (mine operators, residents and the EPA) have expressed their concerns on the impacts and given views, suggestions and solutions on the issue.

Blasting and Transportation were identified, according to the study, by both mine operators and residents as activities that have significantly severe environmental impacts. Both group of respondents also agreed on earthmoving and screening as the activities with the least effect on the environment. Other activities identified by the research which have adverse effects on the environment were excavation, crushing and clearance. These activities give rise to atmospheric pollutants arising from particulate and stack emissions which degrade air quality and constitute primary environmental impacts with serious health consequences. Disturbed ground areas, degraded air quality from stack emissions and impairment of surface and ground water quality were identified as primary environmental impacts from aggregate mining operations in Ghana. Based on the study, it was found out that, construction aggregates miners and nearby residents identified excessive noise from blasting of rock using dynamites, visible deep cracks in walls of surrounding buildings arising from vibration, dust and diesel fumes, fugitive dust blowing from uncovered dump trucks, dust from poorly monitored crushers, and from piles of crushed rock at the construction site, and increased traffic as the major potential cumulative impacts from construction aggregate mining in Ghana. Erosion of exposed areas, loss of wildlife, loss of native plant life (flora), contamination of surface and groundwater, sedimentation associated with the use of heavy machinery, were identified by miners and nearby residents to result in significantly severe land use impacts. Vibration from blasting, noise, dust causing impaired vision, aesthetic degradation and dusty cover as well as traffic congestion and safety hazards are the main environmental impacts from construction aggregate mining that were identified to constitute significantly severe nuisance effect.

The study further identified cold and catarrh, respiratory disorders, and asthma, which arise out of dust and diesel fumes, as major health hazards from construction aggregate mining operations.

People most likely to be adversely affected by the impacts of construction aggregate mining operations are mine workers, nearby residents, and the general public.

It was concluded from the study that from the perspective of the nearby residents, the people living near the construction aggregate mining sites are more likely to be affected than the site workers (67.4% and 64% respectively). Communities close to construction aggregate mining site at Amasaman as well as other stakeholders such as the aggregates miners identified the same three environmental impacts from construction aggregate mining operations that create significantly severe public nuisance as noise, vibration and dust.

The study also concluded that residents and construction aggregates miners identified three significantly severe land use impacts arising from construction aggregate mining including erosion of exposed areas, loss of wildlife habitat, and loss of native plant life (flora). From the perception of the communities and stakeholders however, loss of aquatic biota and the loss of birds and terrestrial faun does not have significantly severe impact on the environment.

From the study, it was concluded that enforcement of air quality permits, covering of dust generating materials, use of less air polluting equipment, and denying permits to mines on unsuitable lands were some measures suggested by the communities close to these construction aggregates sites. Mine operators also suggested the covering of dust generating materials, enforcement of laws on reclamation and dampening of dust generating materials during transport among eleven significantly important measures for controlling environmental impacts from construction aggregate mining.

According to the study, the main law that the Environmental Protection Agency relies on to control the level of noise produced from construction aggregate mining is the EPA Act 1994, Act

490. From the study however, it emerged that this law needs to be reviewed. Apart from the EPA Act 1994, act 490, the regulatory bodies also rely on L. I. 1652 of 1999 to regulate the effects of construction aggregate mining. The EPA also utilizes the assemblies' bye laws in the discharge of its duties. It was concluded from the study that although the E. P. A. requires that companies undertaking any form of construction aggregate mining would carry out Environmental Impact Assessment (EIA) before operations which border on their standards (EPA) in order to minimize the effects their activities have on the environment it was found out from the study that many of the construction aggregate mining firms are operates without the knowledge of the E. P. A. and therefore do not present any Environmental Impact Assessment before commencing operations. This is so because the E .P. A's monitoring and supervisory roles have not been very effective.

Based on the study, it was found out that currently, no major reclamation programmes for degraded areas are planned by stone quarrying and sand and gravel mining operators in Ghana, and degraded mining areas are mainly used as landfills sites, refuse dumps, or are left for natural regeneration. The Minerals Commission, the E. P. A. and other relevant certification bodies should therefore inspect the reclamation programmes of the construction aggregate mining firms before granting them permits. On completion of the operations, the firms should be closely monitored to implement their reclamation programmes.

The research has carefully addressed each objective and therefore shown that though the mining of construction aggregates is important because of its uses, there is the need to mitigate their adverse effects and in order to achieve this the collaborative effort of individuals involved are much needed.

5.2 RECOMMENDATIONS

The main aim of the research was to study the negative impacts that aggregate mining and processing in Ghana have on the environment and to propose measures that will help combat the problem.

In order to achieve this aim, objectives were set out to prescribe directions through which certain findings could be established in order to recommend ways by which the negative impacts of construction aggregate mining can be minimized. The recommendations are in two sections; specific recommendations based on findings from the study and general recommendations.

5.2.1 Specific Recommendations Based on Findings

Based on the findings on environmental impact of construction aggregate mining, the following recommendations are given;

1. The Minerals Commission, the E. P .A and other relevant certification bodies must closely monitor the activities of construction aggregate mining firms to implement their reclamation programmes on completion of their operations.
2. Residents should be educated to report problems arising from aggregate mining to the Environmental Protection Agency (EPA) for them to take the necessary action.
3. Metropolitan, Municipal and District Assemblies (MMDAs) as well as The Environmental Protection Agency (EPA) which have the primary authority for regulating construction aggregate mining should issue local permits for new operations that exceed a certain threshold of activity, or for an expansion of an existing operation. Local permits should address issues such as hours of operation, noise, traffic, dust, erosion control, mitigation of environmental impacts, and reclamation, and performance bonds or some other form of

financial assurance should be required. Mining and reclamation plans may be required along with the permit to allow operations.

4. The Environmental Protection Agency (EPA) must enforce laws and legislation on construction and the environment and apply prescribed sanctions where required to serve as a deterrent to others.
5. Companies must be encouraged to follow the rules and regulations of the Environmental Protection Agency (EPA) and action taken against those in violation.
6. As much as possible, the Environmental Protection Agency (EPA), must conduct regular education for construction aggregate miners and residents on the impacts of construction aggregate mining activities on the environment as well as carry out regular monitoring of construction aggregate mining sites.
7. Enforcement of air quality permits must be strictly adhered to by the Metropolitan, Municipal and District Assemblies (MMDAs) and other authorities whose responsibilities it is to do so.
8. Dust generating materials must be covered properly to and from construction aggregates mine sites.
9. Use of less air polluting equipment, and methods such as the use of water sprays should be encouraged and enforced by the Environmental Protection Agency (EPA).
10. Construction aggregate mining firms should undertake Environmental Impact Assessment (EIA) before their operation begins.

True cooperation is required between construction aggregate mining operators and nearby residents to reduce environmental effects while allowing aggregate extraction to continue. This indicates that the practice of site clearance which is a major cause of ecosystem destruction can be controlled by proper planning site management to cause the least possible disturbance to the site's vegetation in order to reduce the negative impacts of construction aggregate mining on the ecosystem. Reclamation plans must be approved before construction aggregate extraction can begin.

5.2.3 General Recommendations

To minimize the environmental impacts of construction aggregate mining activities, the following recommendations are being given;

1. That The Environmental Protection Agency, Metropolitan, Municipal and District Assemblies (MMDAs), The Minerals Commission and other relevant bodies which have the primary authority for regulating aggregate mining operations must step up regular monitoring of construction aggregate mining sites to enforce bye – laws and see to it that the right thing is being done.
2. The Environmental Protection Agency, Metropolitan, Municipal and District Assemblies (MMDAs) and The Minerals Commission must as a matter of urgency organise regular formal and informal education of residents and construction aggregate mining firms to create an awareness on the environmental impact of construction aggregate mining activities and educate the participants on possible ways of minimizing these environmental impacts.

5.3 AREAS FOR FURTHER RESEARCH

The phenomenon of construction aggregate mining is one activity that will be very difficult if not impossible to stop. This is because so long as the country is developing and expanding its infrastructure in terms of roads, schools, hospitals and all forms of construction activities there will be the need for construction aggregates to achieve the developmental goals of the country. The concern of all however should be adopting measures that will minimize if not eliminate the environmental impact of such construction aggregate mining activities. For future study on the topic of environmental impact of construction aggregate mining in the Greater Accra region – a case – study of Amasaman in the Ga West Municipal, one may include more communities within the catchment area of construction aggregate mining activities in running the same analysis instead of focusing on only one community in the whole region. Of course, the more communities that can be incorporated into the survey will in the long run improve the power in explaining the perceptions and effects such construction aggregate mining activities is having on residents living nearer to these sites. One other area of potential research on the environmental impact of construction aggregate mining in the Greater Accra Region is to investigate into the measures that the various construction aggregate mining firms had adopted in reclaiming land that were degraded and eroded due to their activities as well as the effectiveness of such measures in addressing the issues of environmental impact of construction aggregate mining.

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APPENDIX I

QUESTIONNAIRE FOR AGGREGATE MINERS/AGGREGATE MINING FIRMS

ENVIRONMENTAL IMPACT OF CONSTRUCTION AGGREGATE MINING IN THE GREATER ACCRA REGION

This questionnaire is only for academic purpose. It will help the researcher produce a research report as part of his Msc. course in Construction Management at the Kwame Nkrumah University of Science and Technology, Kumasi. Your response will be treated confidentially. Please, answer the questions as frankly as possible.

A. Background Information

1. Name of person answering (Optional)………..…………………………………........
2. Location of mine site…………………………………………………………………

Please tick where appropriate. Where your response would not be detailed enough, you can give clear reference to documents, articles, situations or events. Where the space provided is not enough, you may write under the line provided or at the back of the page.

3. How long has the mine site been in operation? (in years)

0 – 5 (   )   6 – 10 (   )   11 – 15 (   )   15 – 20 (   )

4. How long will operations in the mine last? (in years)

   0 – 10 (   )   11 – 20 (   )   21 – 30 (   )   31 – 40 (   )

5. How much area is covered by the mine concession? (in hectares)

   0 – 0.50 (   )   0.6 – 2.0 (   )   2.1 – 5.0 (   )   above 5 (   )

6. How many workers are engaged in the mining activities?

   0 – 20 (   )   21 – 40 (   )   41 –60 (   )   61 – 80 (   )   81 – 100 (   )

7. Which type (s) of aggregate mining are you engaged in? (please tick the ones that apply)

   Stones (   )   Gravel (   )   Sand (   )

8. What are the current uses of the materials mined from construction aggregates sites?

   Road construction (aggregates, base, crush rock etc.   (   )

   Building construction (aggregates, fill etc.)   (   )

   Land filling (aggregates, fill etc.)   (   )

   Landscaping (topsoil, fill etc.)   (   )

   Other general construction   (   )

B. Environmental risk associated with aggregate mining activities

9. What primary environmental impacts arise from the construction aggregate mining activities? (please tick all that apply)

   Degraded air quality from stack emissions   (   )

   Disturbed ground areas   (   )

   Impairment of surface and ground water quality   (   )

   Increased traffic on roads   (   )

   Use of scarce water   (   )

   Others (Please specify……………………………………………………………………….....

10. Which among the following list is a potential cumulative impact from the development of a typical stone quarrying site?

   Excessive noise from blasting of rock using dynamites   (   )

   Visible deep cracks in walls of surrounding buildings arisings from vibration   (   )

   Dust and diesel fumes generated on haul roads to and fro the quarry site   (   )

Fugitive dust of larger particles blowing from uncovered or partially covered dump trucks ( )

Fugitive dust or larger particles from poorly monitored crushers and out – of - compliance operations ( )

Fugitive dust from piles of crushed stones at the mines ( )

Increased traffic with a concomitant increase in air pollution from vehicles ( )

Increased air pollution from abandoned mines and until natural re – vegetation stabilizes the surface soil. ( )

Others (Please specify……………………………………………………………………….....

11. Which among the following list is a potential cumulative impact from the development of a typical sand and gravel mining site?

Dust and diesel fumes generated on haul roads to and from the mines ( )

Fugitive dust blowing from uncovered or partially covered dump trucks ( )

Fugitive dust from poorly monitored crushes and out – of – compliance operations( )

Fugitive dust from piles of construction aggregates at the mine ( )

Increase traffic with a concomitant increase in air pollution from vehicles ( )

Increased population with a concomitant increase in disturbed land areas ( )

Increased air pollution from some construction aggregates mines after they are abandoned until natural re – vegetation stabilizes the surface soil ( )

Others (Please specify……………………………………………………………………….....

12. Which land use impacts arise from construction aggregate mining activities? (please tick all that apply)

Loss of wildlife ( )

Erosion of exposed and excavated areas ( )

Sedimentation associated with use of heavy machinery ( )

Loss of native plant life (flora) ( )

Loss of aquatic biota ( )

Loss of in – stream habitat ( )

Loss of terrestrial and aquatic vegetation ( )

Loss of birds and terrestrial fauna ( )

Contamination of soils ( )

Contamination of surface and groundwater ( )

Others, please specify……………………………………………………………………

C. **Communities' and Stakeholders' perceptions on the environmental impacts of aggregate mining for construction.**

13. Which of the following construction aggregate mining activities in your opinion adversely affect the environment? (please tick all that apply)

Clearance ( )

Blasting ( )

Earthmoving ( )

Excavation ( )

Crushing ( )

Screening ( )

Transportation ( )

Others, please specify……………………………………………………………………

14. Which "public nuisance" effects are the results of construction aggregate mining activities? (please tick all that apply)

Dust causing impaired vision, aesthetic degradation and dusty cover ( )

Noise ( )

Vibration from blasting ( )

Bright lights at night ( )

Increase in population ( )

Traffic congestion and safety hazards ( )

Road blocks and diversions ( )

Others, please specify……………………………………………………………………

15. Are your health or the healths of your workers affected in any way by the construction aggregate mining activities?

Yes ( ) No ( )

16. If yes, which of these health hazards are you or your workers afflicted with due to construction aggregate mining activities? (Please tick all that apply)

Respiratory disorders from air-borne particulate emissions ( )

Chronic irritation of the lungs and mucus membrane from gypsum dust ( )

Cold and catarrh ( )

Asthma ( )

Sleeplessness ( )

Stress effects ( )

Others, please specify…………………………………………………………………………

17. Apart from you or the workers of the mine, which other people are likely to be adversely affected by construction aggregate mining activities? (please tick all that apply)

People living near mining sites ( )

The general public ( )

Others, please specify…………………………………………………………………………

18. Identify and rank the level of the disturbance in the case of construction aggregate mining activities using the following scale values. (1 = 'not severe', 2 = 'somewhat severe', 3 = 'severe', 4 = 'very severe' and 5 = 'extremely severe')

Nuisance Effects	Severity				
	1	2	3	4	5
Noise generation					
Dust generation					
Construction traffic					

D. Remedies.

19. Do you as an aggregate miner/aggregate mining firm adopt any strategies in redressing degraded and disused construction aggregate mining sites?

Yes ( ) No ( )

20. If yes, how are degraded and disused construction aggregate mining sites are redressed by your firm?

Reclamation ( )

Planned re – vegetation ( )

Landfill ( )

Refuse dump ( )

Left to natural re – vegetation ( )

Others, please specify……………………………………………………………………

21. What measures do you suggest for checking or controlling environmental impact of construction aggregate mining activities?

Installation silt fencing or sediments basins to capture sediments ( )

Air quality or dust control permit checks and compliance should be enforced strictly and consistently ( )

Time scheduling of noisy operations ( )

Adopt noise abatement measure ( )

Use properly maintained or less air polluting equipments ( )

Cover dust generation materials ( )

Provide water sprays to dampen dust generating material during transportation/storage ( )

Deny operating permits if inactive or abandoned mines could be re – opened to provide the same resources ( )

Deny permits to mines proposed to be located in areas considered unsuitable eg. Near residential areas ( )

Encourage the use of re – cycled materials ( )

Enforce laws on reclamation and re – vegetation of degraded mine areas ( )

Others (Please specify…………………………………………………………………

APPENDIX II

QUESTIONNAIRE FOR THE PUBLIC/NEARBY RESIDENTS

ENVIRONMENTAL IMPACT OF CONSTRUCTION AGGREGATE MINING IN AMASAMAN

(GA WEST MUNICIPAL OF THE GREATER ACCRA REGION)

This questionnaire is only for academic purpose. It will help the researcher produce a research report as part of his Msc. course in Construction Management at the Kwame Nkrumah University of Science and Technology, Kumasi. Your response will be treated confidentially. Please, answer the questions as frankly as possible.

E. Background Information

1. Name of person answering (Optional)……………………………………………..……..........
2. Location of mine site……………………………………………………………..…………

Please tick where appropriate. Where your response would not be detailed enough, you can give clear reference to documents, articles, situations or events. Where the space provided is not enough, you may write under the line provided or at the back of the page.

3. How long have you been resident in your current locality? (in years)

0 – 5 ( ) 6 – 10 ( ) 11 – 15 ( ) 16 – 20 ( )

4. How far is the mine from your place of resident/locality? (in Kilometres)

   0 – 2 ( ) 3 – 5 ( ) 6 – 8 ( ) 9 – 10 ( )

5. How long has the mine site been in operation? (in years)

   0 – 5 ( ) 6 – 10 ( ) 11 – 15 ( ) 16 – 20 ( )

F. Environmental risk associated with aggregate mining activities

6. What primary environmental impacts arise from construction aggregate mining activities in your place of residence or locality? (please tick all that apply)

   Degraded air quality from stack emissions ( )

   Disturbed ground areas ( )

   Impairment of surface and ground water quality ( )

   Increased traffic on roads ( )

   Use of scarce water ( )

   Others (Please specify……………………………………………………………….....

7. Which among the following list is a potential cumulative impact from the development of a typical stone quarrying site close to your area?

   Excessive noise from blasting of rock using dynamites ( )

   Visible deep cracks in walls of surrounding buildings arisings from vibration ( )

   Dust and diesel fumes generated on haul roads to and fro the quarry site ( )

   Fugitive dust of larger particles blowing from uncovered or partially covered dump trucks ( )

   Fugitive dust or larger particles from poorly monitored crushers and out – of – compliance operations ( )

   Fugitive dust from piles of crushed stones at the mines ( )

   Increased traffic with a concomitant increase in air pollution from vehicles ( )

   Increased air pollution from abandoned mines and until natural re – vegetation stabilizes the surface soil. ( )

   Others (Please specify……………………………………………………………….....

8. Which among the following list is a potential cumulative impact from the development of a typical sand and gravel mine site close to your area?

Dust and diesel fumes generated on haul roads to and from the mines ( )

Fugitive dust blowing from uncovered or partially covered dump trucks ( )

Fugitive dust from poorly monitored crushes and out – of – compliance operations( )

Fugitive dust from piles of sand and gravel at the mine ( )

Increase traffic with a concomitant increase in air pollution from vehicles ( )

Increased population with a concomitant increase in disturbed land areas ( )

Increased air pollution from some sand and gravel mines after they are abandoned and until natural re – vegetation stabilizes soil ( )

Others (Please specify……………………………………………………………………......

9. Which land use impacts arise from construction aggregate mining activities in your residential area or locality? (please tick all that apply)

Loss of wildlife ( )

Erosion of exposed and excavated areas ( )

Sedimentation associated with use of heavy machinery ( )

Loss of native plant life (flora) ( )

Loss of aquatic biota ( )

Loss of in – stream habitat ( )

Loss of terrestrial and aquatic vegetation ( )

Loss of birds and terrestrial fauna ( )

Contamination of soils ( )

Contamination of surface and groundwater ( )

Others, please specify……………………………………………………………………

G. Communities' and Stakeholders' perceptions on the environmental impacts of aggregate mining for construction.

10. Which of the following construction aggregate mining activities in your opinion adversely affect the environment in which you live? (please tick all that apply)

Clearance ( )

Blasting ( )

Earthmoving ( )

Excavation ( )

Crushing ( )

Screening ( )

Transportation ( )

Others, please specify…………………………………………………………………………

11. What are some of the negative impacts you have encountered as a result of the construction aggregate mining activities in your place of residence or locality?

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12. Which "public nuisance" effects are the results of construction aggregate mining activities?(please tick all that apply)

Dust causing impaired vision, aesthetic degradation and dusty cover ( )

Noise ( )

Vibration from blasting ( )

Bright lights at night ( )

Increase in population ( )

Traffic congestion and safety hazards ( )

Road blocks and diversions ( )

Others, please specify…………………………………………………………………………

13. Which health hazards arise from construction aggregate mining activities?(please tick all that apply)

Respiratory disorders from air-borne particulate emissions ( )

Silicosis from prolonged exposure to extreme fine particles of silica ( )

Chronic irritation of the lungs and mucus membrane from gypsum dust ( )

Cold and catarrh ( )

Asthma ( )

Sleeplessness ( )

Stress effects ( )

Allergies ( )

Malaria from mosquitoes ( )

Others, please specify…………………………………………………………………………

14. Which people are likely to be adversely affected by construction aggregate mining activities? (please tick all that apply)

Site workers ( )

People living near the aggregates sites ( )

The general public ( )

Others, please specify…………………………………………………………………………

15. Identify and rank the level of the disturbance in the case of construction aggregate mining activities using the following scale values. (1 = 'not severe', 2 = 'somewhat severe', 3 = 'severe', 4 = 'very severe' and 5 = 'extremely severe')

Nuisance Effects	Severity				
	1	2	3	4	5
Noise generation					
Dust generation					
Construction traffic					

H. Remedies.

16. Do the construction aggregates miners/construction aggregates firms adopt any measures to get disused and degraded mines redressed?

Yes ( ) No ( )

17. If yes, how are the degraded and disused construction aggregate mining sites redressed?

Reclamation ( )

Planned re – vegetation ( )

Landfill ( )

Refuse dump ( )

Left to natural re – vegetation ( )

Others, please specify………………………………………………………………………………

18. What measures do you suggest for checking or controlling environmental impact construction aggregate mining activities?

    Installation silt fencing or sediments basins to capture sediments ( )

    Air quality or dust control permit checks and compliance should be enforced strictly and consistently ( )

    Time scheduling of noisy operations ( )

    Adopt noise abatement measure ( )

    Use properly maintained or less air polluting equipments ( )

    Cover dust generation materials ( )

    Provide water sprays to dampen dust generating material during transportation/storage ( )

    Deny operating permits if inactive or abandoned mines could be re – opened to provide the same resources ( )

    Deny permits to mines proposed to be located in arrears considered unsuitable eg. Near residential areas ( )

    Encourage the use of re – cycled materials ( )

    Enforce laws on reclamation and re – vegetation of degraded mine areas ( )

    Others (Please specify……………………………………………………………………......

19. Has the EPA been organizing educational and sensitization programmes for you and others in your place of residence/locality on how to cope with the effects of construction aggregates activities.

    Yes ( ) No ( )

20. If yes, how often have they been organizing educational and sensitization programmes for you and others in your place of residence/locality on how to cope with the effects of construction aggregates activities?

    Weekly ( ) Monthly ( ) Yearly ( )

    Other (please specify) …………………………………………………………………..

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21. How are the educational and sensitization programmes carried out?

Through the newspapers ( )

Through the mass media ( )

Through the public van ( )

Other (please specify) ……………………………………………………………………

APPENDIX III

QUESTIONNAIRE FOR THE ENVIRONMENTAL PROTECTION AGENCY (EPA)

ENVIRONMENTAL IMPACT OF CONSTRUCTION AGGREGATE MINING IN THE GREATER ACCRA REGION

This questionnaire is only for academic purpose. It will help the researcher produce a research report as part of his Msc. course in Construction Management at Kwame Nkrumah University of Science and Technology, Kumasi. Your response will be treated confidentially. Please, answer the questions as frankly as possible.

Where the space provided is not enough, you may write under the line provided or at the back of the page.

1. Which ordinance/bye laws/legislations are in place for controlling excessive noise, smoke or dust levels from construction aggregate mining activities?

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2. Are these ordinance/bye laws/legislations for controlling excessive noise, smoke or dust levels from construction aggregate mining reviewed regularly?
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3. How often are these ordinance/bye laws/legislations for controlling excessive noise, smoke or dust levels from construction aggregate mining reviewed?
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4. How effective have these ordinance/bye laws/legislations for controlling excessive noise, smoke or dust levels from construction aggregate mining been?
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5. What are other legislations enforceable by the EPA concerning construction aggregate mining?

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6. What is the penalty for breach of the above legislations, if any?

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7. Does the EPA carry out routine inspections on construction aggregate mining sites?

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8. How often do you carry out such routine inspections on constructions aggregate mining sites?

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9. What triggers the inspection on construction aggregate mining sites?

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10. Apart from the inspections are there regular educational and sensitization programmes carried out by the EPA for construction aggregates miners?

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11. How often are these educational and sensitization programmes carried out if such programmes do exist?

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