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IMPACT OF MECHANICAL INDUSTRIES ON THE ENVIRONMENT -A CASE STUDY IN TWIFU ATTI MORKWA MUNICIPALITY IN THE CENTRAL REGION OF GHANA

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NOVEMBER, 2017

DECLARATION

STUDENT'S DECLARATION

I, **JOSEPH AFFADZIE**, declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my original work, and it has not been submitted, either in part or whole for another degree elsewhere.

Signature ……..

Date …….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines and supervision laid down by the University of Education Winneba.

Name: MR. C. K. NWORU

Signature ……

Date ……

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I am grateful to Almighty God for His guidance and protection. Secondly, to my supervisor, Mr. C. K. Nworu, Mr. Emmanuel D. Afadzie, Mr. Martin Angmor Narteh, Mr. Ernest Cobbina and Mr. Oswell Mcdermott –Sonny" Rankine.

DEDICATION

To Mr. Oswell Rankine.

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ABSTRACT

The main purpose of the study was to investigate the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality in the Central Region. This study employed case study research design. The researcher used quantitative research approach. The population for this study was the workers of the Twifo oil plantation in the Twifo Atti-Morkwa Municipality. The entire population for this study was 123. Random sampling method was used to select 92 respondents for the study. Questionnaires were the main instrument used to gather primary data. The data collected was analysed statistically using the statistical package for social sciences (SPSS) Version 18. The study results concluded that 75.6% of the respondents agreed that the water bodies are destroyed as a results of the activities of the mechanical industries. Moreover, 76.7% agreed that the air is sometimes polluted as a results of the activities of the mechanical industries. Also, 84.9% agreed that the activities of the mechanical industries produce greenhouse gases like carbon dioxide, chlorofluorocarbons, in their manufacturing process. Moreover, 79.1% agreed that the activities of the mechanical industries creates environmental degradation arising from industrialism. Furthermore, 67.4% said that the kind of improvements that has been done to manage waste water is control system, 15 respondents representing 17.4% said that the kind of improvements that has been done to manage waste water is automatic while 13 respondents representing 15.1% said that the kind of improvements that has been done to manage waste water is manual. Moreover, 29.1% said that lack of environmental technologies (clean technologies applications) affects the improvement of the environmental performance of the factory. The study recommended that the environmental protection agencies and NGOs should continue to monitor the activities of the mechanical industries in order to comply with the environmental protection rules and regulations and ensure the safety of the environment.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Organizations of all kinds are increasingly concerned to achieve and demonstrate sound environmental performance by controlling the impact of their activities, products and services on the environment, taking into account their environmental policy and objectives. They do so in the context of increasingly stringent legislation, the development of economic and other measures to foster environmental protection, and a general growth of concern from interested parties about environmental matters and sustainable development. Preventive engineering approaches use information about how a technology affects human life, society, and the natural ecology in order to adjust engineering methods and applications to achieve the best possible compatibility between technology and its contexts (Young & Vanderburg, 2012). They constitute a new engineering paradigm, aspects of which are emerging in industry and universities. Preventive engineering and pollution prevention, considers the operation and design of processes, products, and materials to reduce negative impact on the natural ecology.

Industry and engineers are functioning today in a changing climate being fuelled by concerns about the sustainability of our way of life and worries about environmental damage. Public concern in the industrialised nations has led to government actions which are the primary environmental pressure for change. Popularised in 1987 by the report of the United Nations World Commission on Environment and Development (2007), sustainable development is a concept which calls upon humanity to make our ways of doing things more compatible with the

natural and social ecologies, protecting nature and advancing the quality of life for all people, particularly for those in the Third World who need it most.

Responses to public and group pressures are bound to continue and are expected to improve the effectiveness of environmental protection. Typical government actions will include recycling mandates on specific products and materials, additional emissions controls for manufacturing facilities, and local and regional remediation clean-up plans. As a result, the scope, intensity and enforcement of regulations will continue to grow, and it clearly will become increasingly expensive for polluters to comply with the laws. Already in 1986 in the United States the administration of and compliance to environmental laws was costing an estimated $10 million per page of government regulation (OTA 2006); today there is in fact a program in the US EPA to reduce the paper volume of environmental legislation (Environmental Manager 2006). It is the author‘s contention that although treated, produced water and drilling waste could still contain quantities of heavy metals and other natural occurring material that are of major concerns to the environment, safety and health. The study therefore investigates the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality.

1.2 Statement of the Problem

The researcher noted that waste in the form of crude petrol containing petroleum residue originating from cleaning operations at a mechanical industry are mostly deposited in a residential area in the vicinity of this oil company. This is unhealthy, very troubling and disturbing as the population of this neighborhood might be exposed to toxic petroleum residue that characterizes this waste. Proponents of environmental management subscribe to an opportunity of institutional learning

where capitalist economies can address environmental problems through the ecological restructuring of industrial production processes targeting improvements in resource efficiency. Thus environmental protection is achievable with substitution of pollutants and non-renewable materials with environmentally friendly and renewable ones, recycling and waste minimization, and reduction in material and energy use (Revell, 2007).

1.3 Purpose of the Study

The main purpose of the study is to investigate the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality.

1.4 Objectives of the Study

The specific objectives of the study includes;

1. To evaluate the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality.
2. To identify the challenges faced by mechanical industries in their attempt to protect the environment.
3. To consider broad-based possibilities for environmental improvements arising from materials selection and product design

1.5 Research Questions

The following research questions would be used for the study;

1. To what extent can the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality be determined?
2. What are the challenges faced by mechanical industries in their attempt to protect the environment?

3. What are the broad-based possibilities for environmental improvements arising from materials selection and product design?

1.6 Significance of the study

This project will be beneficial to the mechanical industries working in the Twifu Atti-Morkwa Municipality and Ghana as a whole. The outcome of the study would enhance environmental protection and health of residents in the Twifu Atti-Morkwa Municipality.

1.7 Scope of the Work

The scope of the project work is limited to the management of waste and environmental protection. The study would be geographically limited in scope to the Twifu Atti-Morkwa Municipality.

1.8 Organization of the Study

The study is presented in six chapters. The First Chapter which is the Introduction covers the background of the study, statement of the problem, objectives of the study, research questions, significance of the study, scope of the study, as well as the overview of the rest of the study. This would be followed by Chapter Two which reviews extensive related theoretical, empirical and conceptual literature on the subject matter. Chapter Three deals with the methodology and organizational profile of the research which comprises; the research design, sources of data, population, sampling techniques, data collection instruments, data analysis techniques and organizational profile. Chapter Four deals with analysis of results. Chapter Five deals with the discussion of results of this study. Finally, chapter six also deals with a summary of the study, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter contains the literature review regarding environmental protection. The chapter covers the theoretical and empirical frameworks of the study. Issues like the Ecological Modernisation Theory, Environmental Innovation, ecological modernization potentials in the International perspectives, a historical overview of Environmental Management Systems, the environmental Management System Process and Planning and Environmental review

2.1 Theoretical Framework of the Study

2.1.1 Ecological Modernization Theory (EMT)

To start with, when using EMT and network model to study industrial systems transformation and adoption of cleaner technologies, we face the challenge that successes of EMT application have been registered in few countries in Western Europe (The Netherlands, Germany) and also that literature and studies related to Ecological Modernisation concept have been rarely employed in many developing countries especially Ghana. Therefore the literature selected for the present research is drawn from authors in the Western Europe and some recent studies carried in South East Asia in the realm of environmental reforms in SMEs.

According to Lam et al. (2015) Ecological Modernization Theory (EMT), founded on Western European institutions in the 1980s, offers a framework through which to explore and explain society‘s response to environmental problems arising from industrial systems (production and consumption). Wattanapinyo (2016), developed a sociological concept on environment-informed industrial transformations,

that shared the view that Ecological Modernization Theory (EMT) can provide some understanding and explanations on how environmental improvements and reforms emerge and how technological innovations, economic actors and market dynamics, political institutions and civil actors can play a key role to transform industrial systems towards adoption of environmental innovations with an ultimate target of sustainability. Proponents of EMT subscribe to an opportunity of institutional learning where capitalist economies can address environmental problems through the ecological restructuring of industrial production processes targeting improvements in resource efficiency. Thus environmental protection is achievable with substitution of pollutants and non-renewable materials with environmentally friendly and renewable ones, recycling and waste minimization, and reduction in material and energy use (Revell, 2007).

Transformation and societal change constitute the core of sociology where Mol and Spaargaren (2016) argue that one of the major tenets lies in understanding how these changes take place most especially in relation to what are the main agents triggering change and which structural properties of social system enable or constrain transformation. It is abundantly clear in the literature that processes of environmental reforms reflecting transformations in technological, social and institutional spheres act as enablers that create favourable and supportive context in which technological prescriptions can be identified and deployed; these transformations are embedded in environmental innovations that initiate ecological restructuring of industrial production and consumption systems (Lam et al. 2015). In the context of this research we consider ecological restructuring of an industrial system as being driven by environmental innovation within firms.

The development of Ecological Modernization Theory (EMT) from mid-1990s has been posited on two conflicting schools of thought propounded by Hajer (2015) and Mol (2015). Hajer's thinking stresses on cultural politics and discourse, claiming the adoption of EMT concepts promotes the interest of the policy elite rather than objective truth. On the other hand, Mol (cited in Revell, 2007) states that EMT is driven by reflexivity of modern institutions (science, industry, civil society and the state), which reorganize themselves to address ecological risks. He further maintains that these modern institutions have successfully reconciled economic growth and environmental risks in the developed industrialized countries. Science and technology are seen to play a crucial and positive role in resolving environmental risks; meanwhile the role of the state in environmental policy is also evolving from: ―eurative and reactive to preventive, from _dosed' policy making to participative, from dirigistic to contextually _steering'" (Mol, 2015, pp.141). This political modernization process involves the shift of responsibilities from the state to the market (most efficient in the management of ecological risks). In this light, Revell (2007) sees industry as a key actor in the environmental reform process, more or less considered by economic agents as a business opportunity. The civil society and public interest groups participate in policy making and act as arbiter between the state and industry.

2.1.2 Key features of EMT

The following five key social transformations are at the centre of ecological modernization (Mol, 2015 cf Revell, 2007). The changing role of science and technology (from perpetrating to preventing environmental problems).

- The increasing importance of market dynamics and economic agents in ecological restructuring (greening of industry)
- The changing role of the state (from _œommand-and-control‘ to contextually _stœring‘
- Changing discursive practices and emerging ideologies (championing the compatibility of economic growth and environmental protection).
- The changing role and ideology of social movements (from radical to reformist).

The aforementioned social transformation pillars ascribed to the ecological modernization project position EM as a major tenet of environmental policymaking in western industrialized nations (Revell, 2007). These pillars can also contribute to build the capacity of actors/institutions to address environmental problems in terms of investments in research and development and promotion of environmental best practices. It is argued in the literature that ecological re-orientation of industrial systems is embedded in environmental innovations. The next section seeks to relate importance of this concept in the context of this research.

2.2 Broad-based Possibilities for Environmental Improvements Arising from Materials Selection and Product Design

2.2.1 Environmental innovation

Environmental innovation is a decisive factor integrated in the core elements of EMT. In addition to technological innovations that drive environmental reforms, the role and importance of society and institutions in industrial transformation is a recent creation (Sprenger et al., 2009; Freier, 2010; Murphy, 2011; Lam et al., 2015). Institutional innovation is here defined as _new norms and behaviour which private or

public institutions adopt to stimulate technological, social and institutional environmental innovation during processes of ecological restructuring‘ (Lam et al., 2015). Institutional innovation can also engrain _… the emergence and creation of new rules which use incentives or obstacles to stimulate more technological, social or even further institutional environmental innovation by social actors, including economic subjects‘ (Sprenger et al., 2009). Freier (2010) maintains that environmental innovation produces transformation of practices and cultures in institutions and societies as well as improvements in economic and environmental performance. The typology of environmental innovation takes two perspectives, ―preventive” and ―reactive” (Lam et al., 2015). The preventive measures aim at prevention/minimization of waste production, pollution and/or environmental degradation at source. On the other hand, reactive or curative measures target the treatment of unavoidable environmental problems attributed to specific processes of an industrial system after pollution has already taken place. This involves the mitigation of pollution, waste and/or environmental degradation using end-of-pipe waste treatment technologies and disposal in an environmentally friendly manner. But it is important to integrate these approaches in environmental policy development for the sake of efficiency and effectiveness. Lam et al. (2015) maintain that institutional transformation relates to the reflexivity of social institutions and actors, for instance governments, industry and we add civil society organizations and media in response to ecological crisis. This view is also shared by Beck arguing that institutional reflexivity process reflects the specific meaning that modern society and institutions attach to environmental crisis and build up the capability that reflect on social conditions and change them as such (Søndergård et al., 2014).

2.2.2 Critiques of EMT

In the context of our study, we do not share the views expressed in the ―weak" version of EMT (Christoff, 2016), which narrowly focuses on environmental concerns such as resource management and inputs, waste management, energy efficiency and pollutant emissions. Here more emphasis is on the monetary value of the environment while marginalizing non-monetary values such as broader social and cultural needs and non-anthropogenic values. This approach is engrained with neo-corporatist style that includes industry representatives and politicians while excluding large population segments in the management of environmental problems. A resilient and more ecologically focused industrial transformation should adopt a ―strong" version of EMT. It advocates sweeping changes to society's institutional structures and economic system making them more resilient and responsive to ecological concerns.

2.2.3 Ecological modernization potentials in the International perspectives (Cameroon)

To begin with, and as stated in the introduction of EMT, there exist little literature and applications of the concept of EM in as much as developing countries are concerned. What then could frame the applicability of EM in the context of Ghana for instance is well expressed by some scholars who argue that:

If ecological modernization theory is to be used to outline a feasible path of environmental reform, it has to be refined, however, to fit the specific local conditions and institutional developments of industrializing countries' (Frijns *et al.,* 2010:257).

In fact some elements of EM theory have been applied in Cameroon with possibilities for expansion. The popularization of the concept of ‗Sustainable Development' in the Brundtland Report, Our Common Future in 1987 by the World Commission on Environment and Development (WCED, 2007), the provisions of Agenda 21 of the UNCED Conference in Rio de Janeiro (1992), triggered an avalanche of environment-related institutional innovations in the 1990s. The Ministry of Environment and Forests was established, National Environmental Management Plan aimed at the integration of environmental policies into the overall economic development strategies of the country with a long-term view. Sustainable industrial development became more important in the policy-making processes rather than solely economic growth.

EMT ideas are evident in the government's key policy documents on the environment. For instance, ‗Law No. 96/12 of 5th August 1996 relating to Environmental management', stipulates in article *9 section b* that: "*The principle of preventive action and correction (through priority at the source reduction) of threats to the environment is by far using the best available techniques at an economically acceptable cost*"

Moreover coercive economic instruments are provided for in environmental policy of Cameroon. "Industrial establishments importing equipment to enable them eliminate green house gases like carbon dioxide, chlorofluorocarbons, in their manufacturing process or in their products, or to reduce any form of pollution shall benefit from a reduction of the custom duty on these equipment; the proportion and duration of which shall be determined by the Finance Law as and when necessary". (Law No. 96/12 0f 5th August 1996 relating to Environmental management, Article 76 sub-section 1)

Environmental modernization has particular resonance with government strategies for improving the environmental performance of the industrial sector. Environmental policy makers create favourable conditions for environmental technology transfer. For instance, enterprises in the foam and refrigeration manufacturing sector benefited from technology transfer to upgrade factory production equipment financed under the framework of the Montreal Protocol to eliminate ozone depleting substances (CFC 11 and 12). This was accompanied by capacity building program of the personnel. Within the implementation of the _Large Marine Ecosystem of the Gulf of Guinea' Project, Cameroon benefited through transfer of equipment and know-how in the quantification and control of industrial effluents (UNIDO, 2012).

Polluting firms have resorted to self-regulation enshrined in EMS. Economic agents and market dynamics play an important role in ecological modernization project. Michelin France is key customer of natural rubber from Cameroon and conducts regular visits to industrial grade rubber suppliers to ensure that quality standards (ISO 9000 and SRM) are respected. This falls within the context of product stewardship. According to Alemagi (2016) industries adopting EMS are driven by pollution reduction, protection of human health and safety of workers, while 94% of industries acknowledged environmental benefits, 76% economic benefits and 35% improved relations with the regulators. The major constrains to EMS adoption were financial, insufficient knowledge and shortage of skilled labour.

Global environmental policy diffusion, international environmental conventions and agreements to which Cameroon is a signatory have impacted environmental policy and institutional developments in Cameroon. For instance, institutionalization of environmental policy planning through the creation of inter-

ministerial Committee composed of government ministries, administrative bodies, industry, NGOs and civil society representatives. Empirical evidence in EM literature indicates that the globalization of environmental problems has shifted the Eurocentric application of EMT to other parts of the world in the recent years and mostly in the Asian region in agro-industries (Sonnenfeld, 2010, Chavalparit, 2016, Wattanapinyo, 2016). In Cameroon environmental research (Alemagi, 2016) and the media have reported on environmental degradation arising from industrialism as stated in the following excerpt:

'*Environmental experts alarmed by industrial pollution in Douala' (*Pefok, 2007*)*

These environmental postulations always call for industries to improve their environmental performance. According to Kemp and Arundel (2008), organisational environmental innovation can contribute to industrial environmental management to be discussed in the following section.

2.3 What is an Environmental Management System?

An environmental management system (EMS) may be defined as a formal set of policies and procedures that define how an organization will manage its potential impacts on the natural environment and on the health and welfare of the people who depend on it (Andrews *et al.,* 2013). This definition is consistent with the ISO 14001 international voluntary standard for EMSs, which has been adopted by many organizations explicitly and used by many others informally as a framework for their EMSs.

2.3.1 A historical overview of Environmental Management Systems

For years, many businesses worldwide have developed their own environmental management procedure. However, it was just recently that formalizing or standardising them became an issue of great concern.

As Andrews *et al.,* (2013) explains, early EMS prototypes were introduced in the late 1970s and 80s in the United states as compliance management procedures, to assure that the various business units of a complex facility or multi-site corporation maintained compliance with environmental regulatory mandates. The proliferation of environmental regulatory requirements in the United States in the 1970s produced significant reductions in air and water pollution discharges and major improvements in both municipal and industrial waste management. They also dominated the attention of both businesses and government, producing a preoccupation with regulatory compliance (Davies *et al.,* 2016, Andrews 2009).

Since the 1980s, many scientific papers have delivered pervasive evidence from cases where pollution prevention has been found economically beneficial, both for the involved companies and for the society (Allenby and Richards, 2014; Cairncross, 2011). Thus, environmental issues came closer to classical business issues. Parallel to insights concerning economic benefits, and closely linked to them, environmental auditing gained wider attention in the United States during the 1980s (Sobonsky, 2009). This process was driven by tougher environmental regulations and with the purpose of avoiding environmental risks (Bell, 1997). As Ammenberg (2013) pointed, all these circumstances were important factors that contributed to a situation where many, mainly large, international firms established environmental strategies and tried to create management systems that incorporated environmental issues.

Along side the above-mentioned developments within the environmental arena, a process of creating international standards for quality management system took place. It was in 1979 that the International Standardization Organization (ISO) established a committee to work with quality management, which led to the release of the ISO 9001 standard in 1987 (Tamm, 2010). Suffice it to say, if EMSs succeeded, it was thanks to the experiences acquired from the implementation of quality management system. ISO 9001 has been a major success, judging by the number of firms having implemented this standard (ISO, 2011).

Environmental efforts have been accentuated by private codes for corporate environmental management, which have emerged over the past fifteen years (Nash and Ehrenfeld, 2016). Examples of early codes include the Chemical Manufacturers Association (CMA) Responsible Care program, the Coalition for Environmentally Responsible Economics (CERES) principles and the International Chamber of Commerce‘s (ICC) Business Charter for Sustainable development. Today, environmental management systems (EMSs) which are intended to steer and control an organization‘s environmental efforts are common elements in the environmental arena (see Ammenberg 2003). EMSs are mainly used by companies but also by other organization such as local authorities to systematically structure their level of environmental performance (Emilsson and Hjelm, 2002; Honkasalo, 2009).

In preparation for the United Nations‘ 1992 –Earth Summit,” the World Business Council for Sustainable Development (WBCSD) issued a visionary declaration asserting the link among the different three components of sustainability (economic growth, environmental protection, and the satisfaction of social needs). The declaration called for –far-reaching shifts in corporate attitudes and new ways of doing business” to achieve environmental and social sustainability. Significantly, the

WBCSD report posed this goal squarely as a great challenge and opportunity for businesses, not just for government. At its initiative, the International Organization for Standardization set up a strategic advisory group to measure ―eco-efficiency," whose efforts led to the creation of the ISO 14000 series of environmental management standards (Schmidheiny, 2012).

In 1996, the International Organization for Standardization published the final version of an International voluntary standard for EMSs, ISO 14001. Other documents in the ISO 14000 series provided more detailed guidance on many EMS related topics, such as environmental auditing procedures, eco-labeling, environmental performance indicators, life cycle assessment etc. Similar procedural standards, varying in some significant details, were adopted in Great Britain (BS 7750) and the European Union the Eco-Management and Auditing Scheme (EMAS).

As Andrews *et al.,* (2003) pointed, the ISO 14001 standard provided an explicit and closely documented procedural template for EMSs, which could be audited and certified by an approved third-party ―registrar" as conforming to the ISO 14001 standard. At a minimum, organizations that adopted the ISO 14001 standard must demonstrate commitments to compliance with all environmental regulations and other requirements, to prevention of pollution, and to continual improvement of their EMS.

Indeed, as of December 2001, an estimated 36,765 facilities worldwide had been certified as meeting the ISO 14001 standard, including 1,645 facilities in the United States. The latter number reflected an increase of well over 50% per year, and more than a five-fold increase since 1998 (Andrews *et al.,* 2013).

2.4 The Impact of Mechanical Industries on the Environment

2.4.1 The Environmental Management System Process

The process of implementing and using an EMS, which is describe below is very similar for systems that are establish in accordance with ISO 14001. It is normally voluntary to establish an EMS, even if there are examples of cases where companies have more or less been forced to implement a standardized EMS (Wilson and Thomas, 2008). The basic idea is to create a management system that supports the organization to fulfil environmental policy commitments, to reach environmental objectives and to achieve economic goals (ISO, 2016; European Commission, 2011).

ISO 14001 contains standards and provides key elements of an effective management system. In addition, they contain requirements vis – à – vis each element. For example, companies must prepare an environmental policy (one of the elements) and ISO 14001 requires that this policy be appropriate, available and documented. The figure 2.1 below shows the basic elements of ISO 14001.

2.4.2 Planning and Environmental Review

Implementation of an EMS normally starts with an environmental review. The review is done to determine how the company affects the environment. It is the requirement to identify the environmental aspects of the operations, defined by ISO 14001 as the elements of organization‘s activities, products and services that can interact with the environment (ISO, 2016). Hence, the organization reviews their activities to identify their environmental aspects. Thereafter, these aspects are assessed by the organization in question to determine which of them are significant; that is the most important.

2.4.3 Environmental policy

One of the requirements for a company is to establish an environmental policy document that is appropriate to the nature, scale and impacts of the company. It is therefore advantageous to carry out the environmental review before the policy is crafted. However, as Ammenberg (2013) explains, the sequence of requirements in the standard is illogical, since requirements concerning the environmental policy are placed before the planning phase (Figure 2.1). An environmental policy is a series of commitment made by the organisation in relation to environmental protection. The policy normally points out key priority areas for environmental efforts and indicates the direction of environmental work.

2.4.4 Legal and other requirements

It is required to have procedures that ensure that applicable legal and other requirements (of environmental relevance) are identified and available. One intention with standardized EMSs is to make sure that companies comply with the identified requirements (Bell, 2007).

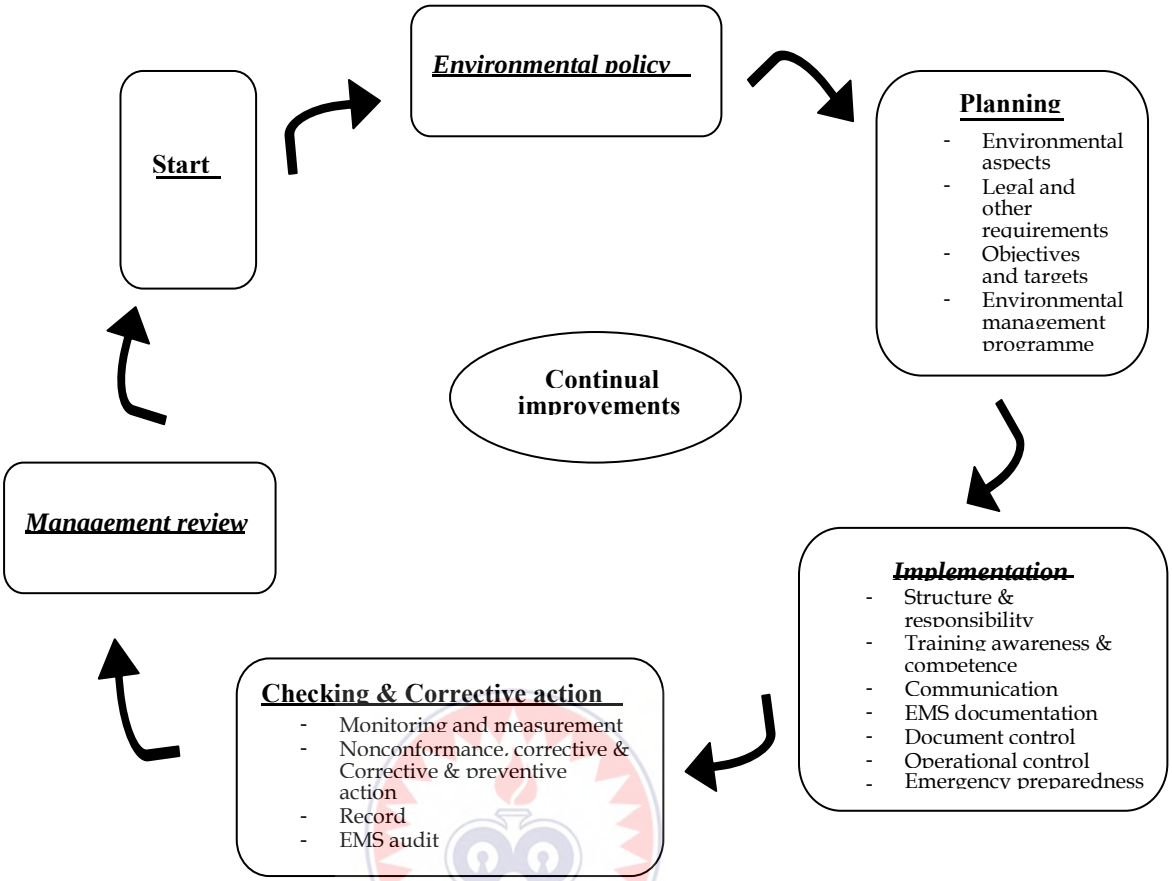

Figure 2.1. Basic elements of ISO 14001

Source: Ontario Ministry of the Environment, (2012).

2.4.5 Objectives, Targets and Programmes

A company using an EMS shall establish objectives and targets, with the aim of achieving environmental performance improvements. These goals are established based on the results of the environmental review, which means that at least some of them should affect the significant environmental aspects. Furthermore, the company should consider the wording in the environmental policy, business requirements and the views of interested parties. As support in the process of achieving objectives and targets, environmental management programmes are established. These programmes, for example, specify responsibilities and time frames.

2.4.6 Implementation, Structure and Responsibility

In order to fulfil the standards requirements, roles, responsibilities and authorities shall be defined, documented and communicated. This is in order to create an effective management system, and implies that essential resources are provided for.

2.4.7 Training, awareness and competence

To become certified, or registered, environmental training needs must be identified and the employees shall have received appropriate training. Each company needs to analyze which employees can have a significant impact on the environment in their work; that is, employees who may affect the significant environmental aspects to a noteworthy extent.

2.4.8 Communication and documentation

Each organization using an EMS shall establish procedures for internal and external communication. Furthermore, well organized documentation is required, which means that core elements of the systems shall be described, as well as their interaction, and that documents must be legible, dated, readily identifiable, maintained in an orderly manner etc. . Further, environmental records of importance shall be stored as well.

2.4.9 Operational control

Procedure, and work instruction to steer activities of environmental significance like waste management, water consumption, hazardous materials, odour and emissions should be established as stipulated by ISO 14001.

2.4.10 Emergency preparedness

ISO 14001 also requires that procedures to identify possible accidents and emergency situations should be identified and established. Thus, provisions for emergency preparedness and response are necessary.

2.4.11 Checking, corrective action, monitoring and measurement

Procedures shall be established for monitoring and measuring key characteristics of operations and activities that can have a significant impact on the environment. The monitoring and measurement activities must be carried out on a regular basis. It is specified that procedures are needed for a periodical evaluation of compliance with environmental legislation and regulations.

2.4.12 Non-conformance and corrective and preventive action

A certified or registered organization must have procedures in place to define responsibilities and authorities for handling and investigating non-conformance, taking to mitigate possible impacts and for initiating and completing corrective and preventive action.

2.4.13 Environmental Auditing

Environmental auditing is required as a follow up strategy to review how the EMS is functioning. Three types of audits exist namely First, Second and Third audits (Almgren and Brorson, 2013). First party audit or internal audits are often carried out by members of staff, an affiliated company or by environmental consultants. In this case the requirements for the auditor to be independent are less strict. Second party audits are carried out on a closely related company, for example a

supplier. Second party audits are not required in ISO 14001 but can be brought up as a means to check suppliers, which indirectly is a requirement in the standard. Third party audits or external audits are carried out by an independent third party. Auditors belong to accredited certification bodies. These certification bodies have been checked by a governmental accreditation body to ensure that they possess the requisite competence. They are approved to carry out audits for certification of an EMS in accordance with ISO 14001 requirements. In most countries there is at least one national accreditation body that has been assigned the task of determining which certification body possesses the required competence to carry out certification auditing. The purpose of environmental auditing procedure is to ascertain whether an organization fulfils the requirements of a standard and other fundamental commitments. After auditing the results are communicated to top management.

2.4.14 PDCA-cycle and continual improvements

According to Deming, (2016), the process of implementing environmental management system elements follows the so- called PDCA- cycle (Plan, Do, Act, Check- cycle). This means that companies:

- Plan: Review the current situation and plan what to achieve.
- Do: Develop strategies, possess and implement them, i.e. carry out the task to make policies, objectives and targets come true (called implementation in the standards).
- Check: Monitor and measure progress, audit their performance against policies, objectives, targets, procedures, etc; and report the results to management (called checking and corrective action)

- Act: Take actions to continually improve performance (called management review).

Conclusively, an EMS is designed in a cyclic way. Based on information from monitoring and regular audits, top management in any given company is required to review the system as a strategy to meet up with the requirements of continual improvement. After review, if need be, the policy is adjusted, new policy and targets are established, training is complemented etc. From an environmental perspective, it is extremely important to note that ISO 14001 does not contain any absolute requirements for environmental performance beyond the commitment to comply with environmental legislation. However, as Ammenberg (2003) elucidates, ISO 14001 contains an important requirement to reach continual improvement in overall environmental improvement. This means that the standards do not establish limits on, for example the amount of energy used or emissions, but require that companies continually improve their performance based on previous situation.

2.5 Environmental Management in industrial enterprises

In the context of this research, we do consider environmental management system as a tool to assist the case company, achieve both environmental and economic goals through greater focus on systemic problems rather than individual deficiencies. As such EMS involves monitoring of risks and the emergence of an in-built system of upkeep and review. The basic elements of EMS are well illustrated by Mebratu (2010). He went further and states that continual improvement as the core element of environmental management results from system-oriented management include: (i) the determination of the root causes of systemic deficiencies, (ii) the identification of opportunities for improvement of environmental performance, (iii)

the development of corrective actions to address root causes, (iv) the verification of the effectiveness of the corrective and preventive measures leading to documentation of changes from process improvements.

New practices that help organizations to avoid or reduce environmental negative impacts can be considered a form of environmental innovation (Renings, 2010). It is reported in the literature that a firm‘s decision to adopt environmental management practices is complex and affects business decision-making and the overall activity of a company (Halila, 2007). According to Gottlieb et al. (2015), many firms prefer pollution control rather than prevention in order to address pollution outside of the production process. ISO certification is one of the Environmental Management Systems adopted in the CDC rubber industry. Improved environmental performance is imbued with some benefits. Therefore, export-oriented companies supplying international markets need to develop environmental management capacity to embrace the challenges of increasingly competitive global markets.

Ecological modernization has both prescriptive and analytical perspectives. Our objective here is to understand how a company‘s social environment (institutions, social structures and actors) influences the adoption of environmental innovations - cleaner technologies - capable of improving the environmental performance of a firm. We draw our inspiration from the triad network (Policy network, business network and civic society network) conceived by Mol (2015), which is theoretically used as an analytical tool to understand the relations between an industrial system and its institutional environment. In order to reflect this in the Cameroon context, we have considered, in the next section, to distinguish the knowledge network (as a network on its own) in the development of a conceptual model called a ―quartet-network

model" to analyze potentials of environmental reforms in the CDC rubber sector. We now move on to analyse concepts related to business, societal, policy and knowledge networks.

2.5.1 Network Analyses: Towards a 'Quartet-network' model

As explained in the previous sections environmental innovations that contribute to ecological restructuring targeting sustainability of an industrial enterprise are better understood by examining the role of actors and institutions in which a particular firm is embedded and that can influence its greening process.

Mol and Spaargaren (2016) argue that environment-informed industrial transformations unfold within dynamic and distinct settings rather than automatically. In order to understand how individual companies, industrial sectors and industrial systems take into consideration ecological risks, it is absolutely necessary to be more precise about the roles being played by both industrial and non-industrial actors under certain conditions. This would require the use of sociological analytical tools that relate industrial firms to the societal, business, knowledge and policy environments, thus constituting a network model. A crucial advantage of the network models lie in their capability to combine both the structural properties of the institutions and the interactions between actors embedded in the network. Networks represent social systems in the sense that actors are involved in almost permanent and institutionalized interactions.

Moreover it is a fact that firms often are confronted with a lack of coordination and are not isolated but are related to - and embedded in complex socio-economic systems and that translating innovative models into reality requires an in depth analysis of the complex social, economic and political relations between the

industrial system, actors and institutions (Kemp et al., 2010; Chavalparit, 2016). The understanding of these existing relations between industrial system and its external environment (government agencies, economic entities, knowledge centres and social actors have two major objectives for this research: (i) identify existing obstacles or drivers that can influence the implementation and introduction of waste prevention and minimization technologies options and (ii) use this understanding to elaborate strategies and build a new knowledge base for the purpose of improving the environmental performance of primary rubber processing industries of the CDC.

Drawing from similar research fields (Mol, 2015; Wattanapinyo, 2016), a systematic analysis of the complex relationship between firms and their social environment would therefore require the employment of an analytical tool that can inform, guide, frame and focus on existing interactions and relations between actors within and outside the industrial system in addition to the institutions that govern and structure these relations and interactions. The appropriateness of network analytical model lies is in its use in similar research studies, complex nature of relations and institutions of the rubber industry and combination of both the institutional structural properties and inter-actor interactions in the construction of a network (Van Koppen and Mol, 2012).

Contemporary innovation studies prime _systems' approaches for innovations at the level of the firm, best understood as involving complex interactions between the firm and its environment, can be captured at two different levels: (i) interactions between firms (i.e. between a firm and its network of customers and suppliers involved in a relatively cooperative relations which shape learning and technology creation; and (ii) broader factors shaping the behavior of firms for instance, the social and cultural aspects, the institutional and organizational framework, infrastructures,

processes which create and distribute scientific knowledge (Kemp et al., 2010). It is further argued that firm level innovation is a variegated, multi-actor process, which occurs in networks (*ibid*)

Wattanapinyo (2016:23) defines networks as –social systems in which actors engage in a more or less permanent, institutionalized interaction." He further claims that a network is a set of actors connected by a set of ties constituting a specific social relation. A network analysis can be defined as the study of social relations among a set of actors in search of how the social structure of relationships around a person, group, or organization affects beliefs or behaviours (Roger, 2016). Network analysis has been used in several cases cited in the literature: data collection and analysis, comparison of relationships between organizations within a network, fundamental intellectual tool for the study of social structures, policy management studies world wide, identification of ways in which weak and strong ties enable or impede firms access to information and expertise cited in Wattanapinyo (2016).

Cases have been reported on the use of network models in ecological modernization research analysis that inform socio-environmental changes in industrial systems (Mol, 2015; Dieu, 2013; Chavalparit, 2016).

Business Network

According to Mol (2015) the _economization of the ecology' plays a key role in the transformation of the industrial system by using economic concepts, actors, mechanisms, institutions and principles. This is buttressed by the emphasis placed on the monetary value of the environment in the EMT. The key players in an economic network logically include economic agents with economic goals and rationality as their primary motive. This interaction would normally be premised on economic rules

and resources between economic agents in industrial chains, systems or sectors. Formal and informal economic rules include markets, ownership, patents, liability, negotiations and cooperation; while economic resources comprise raw materials, scientific and technical knowledge, financial facilities, power, information and access to networks or relationships.

Relations in economic networks can be vertical (input suppliers, producers and final consumers), and horizontal among competing firms in the same sector or through branch organizations; or just neutral relations with economic agents such as banks, insurance companies, research institutes, infrastructure companies. The CDC rubber processing factories with export-oriented corporate strategies are affected in one way or the other by these interactions. This will then give us an opportunity to use this concept of the quartet model to analyse and assess the degree of enablement of economic actors, institutions and interactions in the quest to improve effluent management in the CDC rubber factories and still generate income.

Policy network

The concept describes and analyzes the relations between the public and private actors in some policy areas. Wattanapinyo (2016) claims that policy networks depict a group of public and private actors interconnection based on resources such as information, expertise, money and legitimacy. In the specific case of industrial restructuring driven by environmental values, the main emphasis is placed on government-industry relations that generate policy incentives or disincentives (legislation or institutions) to support industrial sectors. The discourse is on policy processes, dynamics, power relations, institutionalized patterns, changing roles of government and partnerships between industry and government.

Civic society network

Societal network analysis in this study shall be used to examine the interactions between factories and the civil society that may effect some changes (externally) in the production processes and products. Civil society shall be understood in the context of our study as local communities, local and national social organizations and institutions that govern and ―voice out" the interests and concerns of the civil society such as media, NGOs, community groups, women associations. The objective of the social network analysis is to discern the character of the relationships such as the level of interdependency among actors and resource used (scientific information on industrial environmental problems, mobilization of state intervention and dissemination of ideas/interests via the media to galvanise general public backing). Whilst the civil society mechanisms in their interaction with industry (in highly developed economic and democratic societies) include the following: Regular or irregular communications, negotiations, product campaigns, protests at company headquarters, monitor and control enforcement of regulations, pressure on the state act to and creation of general public awareness, capacity building of target groups on industrial ecological crisis and mitigation/prevention approaches; NGOs are yet to be entrenched in most developing countries as for the case of Ghana. However, and fortunately, we are of the opinion that there exist potentials to strengthen the notion of community rights to know, whereby information and monitoring requirements (about accessibility to environmental information and facilities to allow meaningful interpretation of the data) of industrial activities can empower active citizens. As such, what we intend to emphasise here is that community-driven regulation has the potential to growth in importance in the near future in the case of a direct environmental impact on the community.

Knowledge network

The improvement of the environmental performance of the CDC rubber industry is most likely if environmental knowledge and public awareness among actors and institutions are taken into consideration in environmental policy and management of an industrial enterprise. These factors are embedded in the knowledge network of a company. Knowledge networks can be described as the conditions, under which environmental knowledge is produced, distributed, interpreted and applied (Jänicke, 2007). Jänicke further claims that available knowledge about threats and options, environmental consciousness constitute an immediate and crucial resource for environmental actors since lack of knowledge translates to no (noticeable) environmental problem, no public awareness and definitely a stalled policy process. Thus capacity in environmental protection is associated with improvements in informational and communicative capacities of the stakeholders of an enterprise. According to Hansen et al. (2012) knowledge network is composed of suppliers, customers, environmental authorities, technological service centres, knowledge research institutes and universities etc. The claim here is that it is through these networks that actors and institutions reflect, perceive and communicate environmental knowledge capable of ecologically restructuring of an industrial system.

2.6 Empirical Framework

2.6.1 Pollution Prevention

Preventive engineering approaches use information about how a technology affects human life, society, and the natural ecology in order to adjust engineering methods and applications to achieve the best possible compatibility between

technology and its contexts (Young and Vanderburg 2012). They constitute a new engineering paradigm, aspects of which are emerging in industry and universities. This chapter discusses one area of application of preventive engineering, pollution prevention (P2), which considers the operation and design of processes, products, and materials to reduce negative impacts on the natural ecology. The life cycle approach is introduced as a conceptual framework with which to examine flows of materials from "cradle to grave", and as a component of the product cycle of design, production, use and discard.

Industry and engineers are functioning today in a changing climate being fueled by concerns about the sustainability of our way of life and worries about environmental damage. Public concern in the industrialised nations has lead to government actions which are the primary environmental pressure for change. Popularised in 1987 by the report of the United Nations World Commission on Environment and Development [2007], sustainable development is a concept which calls upon humanity to make our ways of doing things more compatible with the natural and social ecologies, protecting nature and advancing the quality of life for all people, particularly for those in the Third World who need it most.

Responses to public and group pressures are bound to continue and are expected to improve the effectiveness of environmental protection. Typical government actions will include recycling mandates on specific products and materials, additional emissions controls for manufacturing facilities, and local and regional remediation clean-up plans. As a result, the scope, intensity and enforcement of regulations will continue to grow, and it clearly will become increasingly expensive for polluters to comply with the laws. Already in 1986 in the United States the administration of and compliance to environmental laws was costing an estimated

$10 million per page of government regulation (OTA 2016) (Figure 2.2); today there is in fact a program in the US EPA to reduce the paper volume of environmental legislation [*Environmental Manager* 2016].

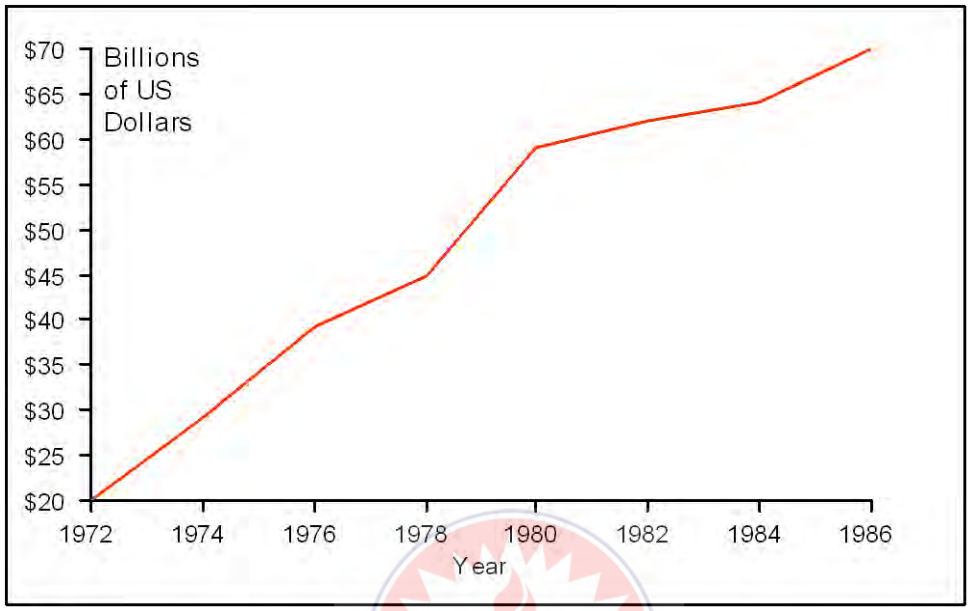

Figure 2.2: The increasing costs of environmental regulation [after OTA 2006].

Source: Bell, (2007). The ISO 14001 Environmental Management System Standard-One American's View

Another pressure on industry is the greening of public values: the environment has now become a direct issue of commercial competition and marketing. Because the green image a company cultivates is linked directly to the real performance of its operations and products, companies are further encouraged to be environmentally responsible. Additional incentives to change include: the rising costs of waste disposal, liability insurance (Brown 2011), worker health and safety protection, and concerns about the scarcity and vulnerability of materials and energy resources (Kempfer 2011).

As elsewhere, the old adage that "prevention is better than cure" also applies to pollution. Pollution prevention offers a route to an environmentally sustainable

way of life, avoiding many of the environment-economy conflicts that hamper traditional strategies. Using life-cycle approaches for product pollution prevention is common sensical. Because prevention means "taking advance measures against something probable or possible" [Webster's dictionary], the most effective preventive actions occur furthest up the life cycle stream. Clearly, problems that have already been curtailed do not carry downstream and continue to be problems. Conceptually, it is observable using a life-cycle perspective that pollution prevention results in the reduction of downstream burdens, environmental and economic.

Pollution prevention broadly encompasses technological and social activities which result in the non-generation or reduction of waste or its toxicity over the entire life cycle of products and activities. It requires a new way of thinking, away from after-the-fact focusing on waste at the "end-of-pipe", to thinking instead about fully integrating clean and preventive criteria within the design, development, production, and consumption of products and services. Thus pollution prevention initiatives protect nature and human health at the most fundamental level, before they are threatened.

According to Freeman et al. (2012), the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. ... includes practices that reduce the use of hazardous materials, energy, water, or other resources and practices that protect natural resources through conservation or more efficient use." Prevention of waste generation: Activities in production, which consist of the substitution and the reduction of the use of raw materials, the change of the performance of existing and the design of new processes and products, resulting in the non-generation or the reduction of waste and/or its pollution potential, in the materials life cycle (van Weenen 2010). Any action that reduces or eliminates the

creation of contaminants, right at their source (Ontario Ministry of the Environment 2012).

2.6.2 The Benefits of Pollution Prevention

For business, perhaps the most unsettling consequence of the environmental pressures mentioned above is the climate of uncertainty, in which long-term decision-making is difficult and risky. A pollution prevention strategy promotes economic stability and other business goals (Porter 2010) because the costs and hazards of managing pollution and dealing with regulations are reduced or avoided all together. This is especially true for unforeseen future costs arising from new regulation, as well as the immediate costs facing a polluter. Furthermore, an effective prevention strategy is fully integrated into the day-today engineering and management of a firm and thus encourages technological innovation and development (OTA 2006, Hirschhorn 2008). 3M corporation, for example, is one notable business progressing in this direction; over the last 15 years, the company has earned over $500 million in first year savings under their *Pollution Prevention Pays* Program (3M 2010).

Pollution Prevention (P2)

A distinction is made between process P2 and product P2 (Figure 2-6). Process P2 aims at improving production systems and unit operations within production, to reduce or prevent wastes at source. Product P2 aims to reduce the future possibility of wastes resulting from the production, use, and disposal of products and is essentially the environmental life cycle design of products, wherein the entire existence of the product and its attributes are analysed and evaluated at all life-cycle stages.

2.7 Pollution Prevention Strategies

A useful division is drawn between those approaches to pollution prevention that are product-focused and those that are process-focused. Note that the fifth item on the process list in fact links to the product strategies.

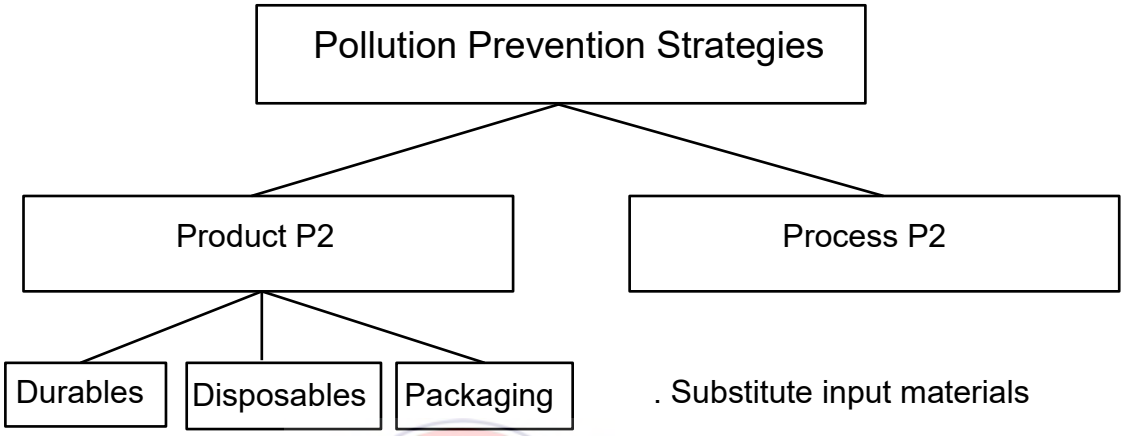

Figure 2.3: Pollution prevention strategies

Source: Field survey (2017)

In a life-cycle sense, product P2 is more radical than process P2 and consequently can be more preventive. Changing products will also change processes. However, process P2 improvements are often more straightforward and are more likely to be implemented in the short-term before radical product design changes would be. Consequently, effective process improvements can result in large and quick P2 benefits. When the most critical waste streams and hazardous systems are considered, process P2 can be particularly effective in reducing important waste and pollution burdens. Preliminary results of process P2 in some industries indicate reductions in quantities of serious wastes of 80% (OTA 2016); this is achieved by improving operating procedures and by changing to available but better technologies and equipment: that is by applying primary and secondary approaches of process P2.

In 1986 in their consideration of P2, the OTA suggested industrial process pollution prevention techniques fall under five broad categories for source reduction of wastes as indicated in Figure 2-3 (OTA 2016). The first three categories are relatively conventional routes to cleaner production, such as improving the efficiency of processes and closing loops to avoid emissions. A common example of the first category, changing input materials, is to substitute a benign water-based alternative for a toxic organic-based solvent. The last category is more fundamental in character, since it crosses from process to product P2 — redesigning and reformulating products to prevent wastes demands a complete reworking of the processes involved over the entire product cycle of the system, from the initial conceptual stages of design, through to production, distribution, use, and discard.

Alternatively, Allen described three stages for a process P2 strategy, based on the order in which they can most easily be accomplished and are most likely to result in the greatest benefits (Allen and Behmanesh 2014):

- improving operating procedures and housekeeping
- changing to cleaner technologies and equipment that are readily available (i.e., using best available technology)
- changing to new clean technologies and equipment that first require development.

Improving production procedures includes better housekeeping, inventory control and material handling — practices for effective management and good engineering which, besides being common sense for other reasons, can dramatically reduce waste and improve efficiencies. Process improvements that are placed higher on the list in Figure 2-3 have proved to be the quickest and most accessible means for

P2 — it is relatively painless for an organisation ~~to~~ pick the low hanging fruit" before moving onto more complex projects.

2.7.1 Product Pollution Prevention

As one considers the concept and practice of pollution prevention, one soon realizes that it is the decision-making behind processes and products that is the foundation of the most important changes. Design, where decisions and choices are made before they are acted upon, is the logical starting point for product P2. This is true of other areas of preventive engineering but for pollution prevention it has been considered to the point where a number of approaches and projects have been developed.

It is generally claimed that about 85% of total life cycle economic costs are committed by the final design of a product, before production or construction actually begin (Fabrycky 2007, Gatenby and Foo 2010, Fabrycky and Blanchard 2011). Similarly, environmental life-cycle impacts resulting from product creation, use and disposal are largely determined by original design. Thus the intellectual and "on paper" activities of design have direct links to consequent environmental effects. Designing for pollution prevention is a very logical path for effective waste reduction. Only recently, however, have disposal options and environmental impact been incorporated as initial design criteria (Keoleian and Menerey 2014).

A hierarchical framework of life cycle design and source reduction approaches is presented in under product P2 in Figure 2-3. This simple hierarchy recognises that it is processes that consume resources and generate wastes, not products per se, although in the process of using a product many impacts occur. As outlined above, that conceptual design fundamental determines the physical activities that follow:

resource engineering, manufacturing, the way a product is used, and final disposed. The hierarchy, therefore, describes categories of engineering from the easiest and most straightforward actions to more complex and radical changes. Operationallising this concept is a formidable challenge faced by engineers and other professionals (Adamson 2014, Hirschhorn and Oldenburg 2010, Freeman *et al.* 2012).

It is generally proposed that managers and technologists look to prevention analysis and methods in order to improve the environmental soundness of products and services. Of assistance are a number of recent bodies of literature which emphasise principles and techniques of prevention (Keoleian and Menerey 2014):

1. 3R's approaches and management (reduce, reuse, recycle),
2. preventive hazardous waste management,
3. waste minimisation, pollution prevention, and source reduction,
4. product stewardship and responsibility, and
5. design for environment/recyclability/disassembly.

Generally, it appears that product P2 approaches utilise a life cycle approach, like that prescribed by the LCA method.

Ultimately environmental impacts, as indicated by resource depletion and pollution, are a function of design. Product P2 practices are starting to demonstrate that, when used creatively, a preventive life cycle approach can identify the priorities practically and define the trade-offs required for meaningful improvements that benefit the environment.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter presents the methods and techniques that the researcher used in the collection and analysis of the empirical data on the field of study. In the first part, the researcher deal with the orientation of the research which is basically rooted in epistemological and ontological considerations and influences the strategy employed in this research and the rationale for adopting or choosing that strategy. Secondly, the research design is also presented and then the data collection methods that was used in the study were discussed. Sampling and the sample technique that was used in getting the respondents to elicit the information that was needed.

3.1 Research Design: Case Study

As indicated earlier, there is the need to have a design in the conduct of research and in the words of Bryman (2008: 31): "the design provides a framework for the collection and analysis of data". In essence, the design influences and determines your choice of the methods to use in the collection of your data. Basically, five prominent designs are outlined by Bryman and involve the experimental design, cross-sectional design also known as survey research, longitudinal design, case study and comparative design. For my research, I have employed a case study design because it involves looking at the social and environmental impacts of mechanical industries activities in a specific place which is the Twifu Atti Morkwa Municipality as a single case study. Using such a single case study of an area would mean that as per the tenets of qualitative research strategy, the issue of generalization would be limited to the context of the study as opposed to that in quantitative research where

the use of a case study would result in a careful selection of a sample that is representative enough to be generalized beyond the context in which the study is being carried out.

3.2 Research Approach

In the conduct of research, there is the need to identify the major approach through which the quest to obtain knowledge would be used. The approach to be used largely depends on the nature of the study. Basically, the researcher operates in two major worlds in his approach to gaining knowledge. This is the epistemological and ontological world. According Bryman (2008:13) epistemological considerations is mainly concerned with the question of what is ―regarded as acceptable knowledge in any discipline of study". The epistemological consideration is rooted in two major traditions of ‗positivism' and ‗interpretivism'. The positivist approach is firmly grounded in the natural science approach to studying social reality and advocates ―the application of the methods of the natural sciences to the study of social reality and beyond" (Bryman. 2008:13). The implication is that the study of social reality should follow similar methods as used by natural scientists such as experiments and survey in the study of social reality. This approach believes in the objective nature of social facts that should be studied and presented in an objective manner independent of subjective intuition and introspection. On the other hand, the interpretive epistemology recognizes the ―distinctiveness of social reality as against that of the natural order" (Bryman, 2008: 15). The approach recommends that the study of social reality requires that the scientist understand the subjective interpretation and meaning that individual social actors attach to social reality and advocates that the researcher empathize (Bryman, 2008: 16). This is because there is the belief that people within

any social setting make meaning out of their social world and hence acts, feel and think in the way they understand. The researcher should therefore set himself to understand how people think, feel and act and the meanings they attach to their actions.

The other approach to gaining knowledge which is the ontological approach questions whether the entities of the society ―can and should be considered objective entities that have a reality external to social actors or whether they are the result of social constructions built from the perceptions and actions of social actors" (Bryman, 2008: 18). It is also based on two major assumptions of objectivism and constructionism. The objectivist approach asserts that social reality and their meaning to which the researcher sets himself to study is external to the social actors and it is independent of them (Bryman, 2008: 19). Hence, social reality and facts are objective ‗out there' and social actors merely have to adjust to them because it existed even before they were born. They merely have to adjust to the existing meanings that are objective and independent of their own thinking and understanding. The constructionist ontology on the other hand asserts the continuality of social reality and its meaning being constructed by the social actors themselves (Bryman, 2008: 19). In effect, people make sense and meaning out of social phenomena and the researcher's responsibility is to understand these meanings that the actors construct. Importantly, the constructionist approach also recognizes the dynamic nature of meanings that people construct and as a result there are variations in how people construct meaning at any place and any point in time.

The researcher is faced with these major worlds of gaining knowledge. The researcher choose to operate in an epistemological interpretivism and an ontological constructionist considerations. Basically, the focus is to study people in their natural

setting and to understand their perceptions, beliefs and meanings they attach to social phenomena and reality that confronts them in their natural setting. In trying to understand the social reality, the adoption of an interpretivist and constructionist approach ensured that the researcher was able to deeply delve into the subjective meanings that individual actors within the social setting attribute to social phenomena and reality they face. The researcher therefore employed methods that helped me understand their social world and their constructions. The approach adopted is therefore very useful. Adopting a positivist and objective approaches on the other hand, the researcher recognized would not be very helpful in understanding the perceptions and beliefs of the people in their social reality since the basic tenets of the approach is to discover objective facts that would be presented objectively as possible and expressed in a _cause and effect' relationship which is not the focus of my study. Hence, the adoption of an interpretivist and constructionist approach which subsequently influenced the research strategy that the researcher adopted in this study.

3.3 Research Strategy: Quantitative or Qualitative Research Strategy

The adoption of an interpretative epistemology and constructionist ontological approaches ultimately influenced my adoption of a strategy for my research. Two major research approaches are used namely the qualitative research strategy and quantitative research strategy even though some researchers use a third strategy known as mixed method that "integrates the qualitative and quantitative research strategies in a single project" (Bryman, 2004: 452). In this study, the researcher employed both quantitative and qualitative strategy. According to Gubrium and Holstein (2007 cited in Bryman, 2008: 367), qualitative research follows four major traditions and fundamentally, one of such traditions is naturalism. By this, qualitative

research seeks to ~~–u~~nderstand social reality in its own terms, as it really is; provides rich description of people and interaction in natural settings" (Gubrium & Holstein, 2007 cited in Bryman, 2008: 367).

The researcher sought to `understand the real social and environmental impacts of mechanical industries on the Twifu Atti Morkwa Municipality. However, to be able to understand the real impacts of mechanical industries and their activities on the areas of operation, the mixed research strategy have been adopted since it provided the researcher with the opportunity to observe, understand, assess and explore the nature and extent of the impacts of mechanical industries activities in depth and to see the situation as it is without being speculative. Since the research demands that the researcher also make contact with the cross section of stakeholders in the mechanical industries which involves the indigenous people themselves as well as management of the mechanical firms, it was feasible to employ combined qualitative data collection methods. Specifically, qualitative data collection methods of interviewing and observation were used.

3.4 Population

According to Ary, Jacobs and Rezavieh (2002), population is used to refer to the entire group of individuals to whom findings of a study apply. The population for this study would be the workers of the Twifo oil plantation in the Twifo Atti-Morkwa Municipality. The entire population for this study was 123.

3.5 Sample Size

According to Krejcie and Morgan (1970), a population of 123 requires a sample size of 92. Therefore, 92 respondents were randomly selected from the Twi oil palm plantation in the Twifo Atti-Morkwa Municipality.

3.5.1 Sampling Technique

The random (probability) sampling technique was used to sample the workers in the company within the study area to collect data in order to predict and generalized the whole research population. This method was used because all elements in the population have an equal chance of being included in the sample. It also minimized the possibility of an unrepresentative sample. This however can be time consuming process (Fisher 2010). The ever increasing need for a representative statistical sample in empirical research has created the demand for an effective method of determining sample size. To address the existing gap, Krejcie and Morgan (1970) came up with a table for determining sample size for a given population for easy reference. According to the Krejcie and Morgan (1970), table of determining sample size, a population of 123 requires a sample size of 92. Moreover, the lottery technique was used to select the workers for the study. This method of sampling therefore ensured that all respondents had an equal opportunity of being selected for the study.

3.6 Research Instrument Used

Data were collected using a structured written questionnaire and interview guide.

3.6.1 Questionnaire

Questionnaires were designed and distributed to the respondents in the company. Closed and open ended questionnaire items were designed to collect primary data; this is because it has proven to be consistent and popular method of data

collection. The questionnaire covered items which helped me to get information regarding the impact of mechanical industries on the environment.

3.7 Piloting the Instruments

The instrument was piloted at the Twifo oil plantation in Twifo Atti-Morkwa Municipality. The pilot questionnaire was given to twenty respondents to gather their views and responses. Their comments were considered before the actual administration of the questionnaire based on the issues emerging from the questionnaire data, a semi-structured interview was piloted at the place and with the same participants.

3.8 Data Analysis

The data collected was first edited to check contradictions and ensure consistency. The edited responses were recorded and analysed statistically. SPSS version 18 was used to analyse data. The main statistical technique employed was percentages; tables were used to explain certain findings. Percentages of the Respondents and their respective views on some important issues. This was used to discuss the collected data.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF RESULTS

4.0 Introduction

This chapter presents the results of the study and discussed the findings. The presentation and discussion of results is based on the research objectives of the study. The chapter covered the following research objectives including to investigate the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality, to consider broad-based possibilities for environmental improvements arising from materials selection and product design and to identify the challenges faced by mechanical industries in their attempt to protect the environment. Out of 92 questionnaires sent out for primary data, 86 questionnaires representing 93% were retrieved while six (6) questionnaires representing 7% were not retrieved.

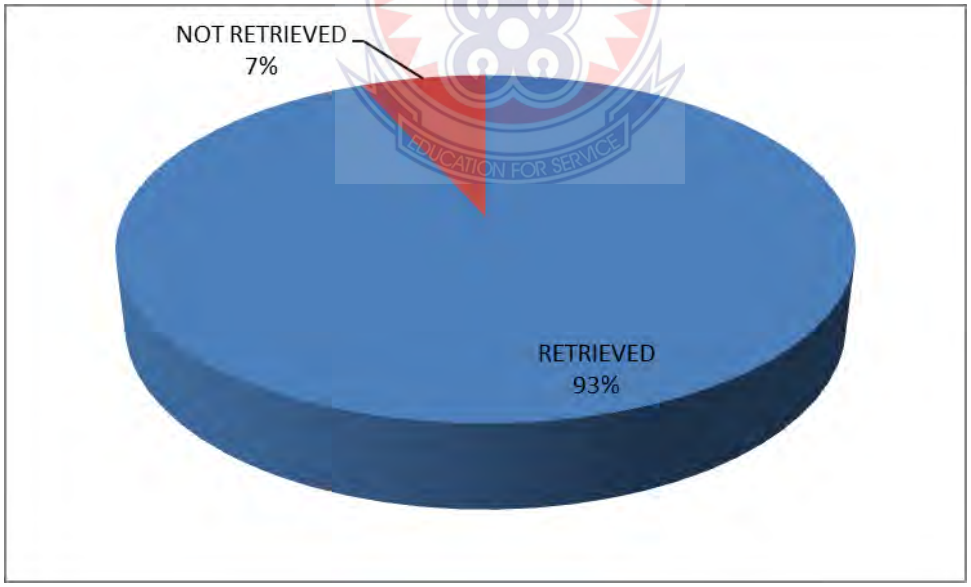

Figure 4.1: Response rate

Source: Field survey, 2017

Table 4.1: Demographic information of the respondents

Gender of the respondents	**Frequency**	**Percentage**
Male	74	86
Female	12	14
Total	**86**	**100**
Age ranges of the respondents		
Below 25 years	5	5.8
26-45 years	16	18.6
36-45 years	37	43
46-55 years	22	25.6
56-65 years	6	7
Total	**86**	**100**
Highest level of educational qualification		
SSSCE/WASSCE	24	27.9
Higher National Diploma (HND)	47	54.7
Bachelor‘s degree	11	12.8
Masters degrees	4	4.7
Total	**86**	**100**
Working experience of the respondents		
1-5 years	14	16.3%
5-10 years	23	26.7
10-15 years	32	37.2
15-20 years	11	12.8
20 years and above	6	7
Total	**86**	**100**
Availability of environmental protection plan in place		
Yes	24	27.9
No	43	50
In progress	19	22.1
Total	**86**	**100**

Source: Field survey, 2017

Table 4.1 indicates that 74 respondents representing 86% were males while 12 respondents representing 14% were females. Moreover, 37 respondents representing 43% were between the age ranges 36-45 years, 22 respondents representing 25.6% were between the age ranges 46-55 years, 16 respondents representing 18.6% were between the age ranges 26-35 years, 6 respondents representing 7% were between the age ranges 56-65 years while 5 respondents representing 5.8% were below 25 years. To add more, 47 respondents representing 54.7% were Higher National Diploma

(HND) holders, 24 respondents representing 27.9% were SSSCE/WASSCE certificate holders, 11 respondents representing 12.8% were Bachelor's degrees holders while 4 respondents representing 4.7% were Masters degrees holders. The study shows that 32 respondents representing 37.2% had 10-15 years working experience, 23 respondents representing 26.7% had 5-10 years working experience, 14 respondents representing 16.3% had 1-5 years working experience, 11 respondents representing 12.8% had 15-20 years work experience while 6 respondents representing 7% had more than 20 years work experience in the mechanical industries. Moreover, 43 respondents representing 50% affirmed that currently an environmental protection plan is not in place, 24 respondents representing 27.9% said that there is an environmental protection plan in place while 19 respondents representing 22.1% said that the environmental protection plan is in progress.

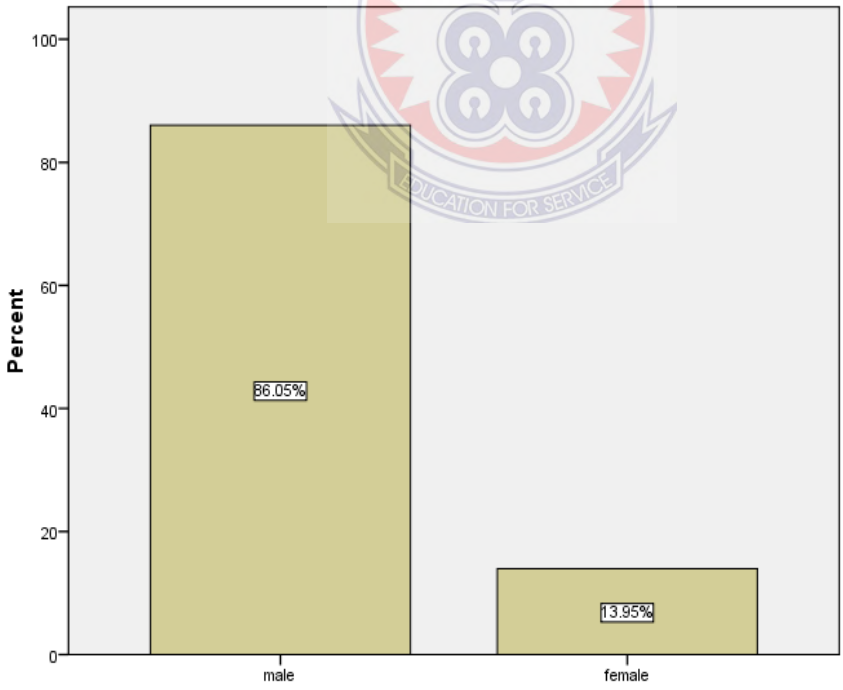

Figure 4.2: Gender of the respondents

Source: Field survey, 2017

Figure 4.2 indicates that 74 respondents representing 86% were males while 12 respondents representing 14% were females.

4.1 The impact of Mechanical Industries on the Environment in Twifu Atti-Morkwa Municipality.

Table 4.2 shows the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality.

Table 4.2: The Impact of Mechanical Industries on the Environment

Statements	Agree f(%)	Not sure f(%)	Disagree f(%)	Total f(%)
The water bodies are destroyed as a results of the activities of the mechanical industries	65 (75.6)	12 (14)	9 (10.5)	86 (100)
The air is sometimes polluted as a results of the activities of the mechanical industries	66 (76.7)	10 (11.6)	10 (11.6)	86 (100)
The activities of the mechanical industries produce green house gases like carbon dioxide, chlorofluorocarbons, in their manufacturing process	73 (84.9)	6 (7)	7 (8.1)	86 (100)
The activities of the mechanical industries depletes the ozone layer.	77 (89.5)	3 (3.5)	6 (7)	86 (100)
Environmental Management Systems are driven by pollution reduction, protection of human health and safety of workers.	75 (87.2)	4 (4.7)	7 (8.1)	86 (100)
The major constrains to EMS adoption were financial, insufficient knowledge and shortage of skilled labour.	75 (87.2)	4 (4.7)	7 (8.1)	86 (100)
The activities of the mechanical industries creates environmental degradation arising from industrialism.	68 (79.1)	9 (10.5)	9 (10.5)	86 (100)

Source: Field survey, 2017

Table 4.2 shows that 65 respondents representing 75.6% agreed that the water bodies are destroyed as a results of the activities of the mechanical industries, 12 respondents representing 14% were not sure, while nine (9) respondents representing 10.5% disagreed. Moreover, 66 respondents representing 76.7% agreed that the air is sometimes polluted as a results of the activities of the mechanical industries, while 10 respondents representing 11.6% disagreed and were not sure respectively. These findings are in agreement with Freeman *et al.,* (2012), the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. ... includes practices that reduce the use of hazardous materials, energy, water,

or other resources and practices that protect natural resources through conservation or more efficient use."

Also, 73 respondents representing 84.9% agreed that the activities of the mechanical industries produce green house gases like carbon dioxide, chlorofluorocarbons, in their manufacturing process, seven (7) respondents representing 8.1% disagreed, while 6 respondents representing 7% were not sure. This finding agrees with UNIDO, (2012), Moreover coercive economic instruments are provided for in environmental policy of Cameroon. –Industrial establishments importing equipment to enable them eliminate green house gases like carbon dioxide, chlorofluorocarbons, in their manufacturing process or in their products, or to reduce any form of pollution shall benefit from a reduction of the custom duty on these equipment.

The study shows that 75 respondents representing 87.2% agreed that Environmental Management Systems are driven by pollution reduction, protection of human health and safety of workers, 7 respondents representing 8.1% disagreed while 4 respondents representing 4.7% were not sure. The study results indicate that 75 respondents representing 87.2% agreed that the major constrains to EMS adoption were financial, insufficient knowledge and shortage of skilled labour, seven (7) respondents representing 8.1% disagreed while four (4) respondents representing 4.7% were not sure. According to Alemagi (2016) industries adopting EMS are driven by pollution reduction, protection of human health and safety of workers, while 94% of industries acknowledged environmental benefits, 76% economic benefits and 35% improved relations with the regulators. The major constrains to EMS adoption were financial, insufficient knowledge and shortage of skilled labour. The basic elements of EMS are well illustrated by Mebratu (2010). He went further and states that

continual improvement as the core element of environmental management results from system-oriented management include:

(i) the determination of the root causes of systemic deficiencies,

(ii) the identification of opportunities for improvement of environmental performance,

(iii) the development of corrective actions to address root causes,

(iv) the verification of the effectiveness of the corrective and preventive measures leading to documentation of changes from process improvements.

Moreover, 68 respondents representing 79.1% agreed that the activities of the mechanical industries creates environmental degradation arising from industrialism, while nine (9) respondents representing 10.5% disagreed and were not sure respectively. In Cameroon environmental research (Alemagi, 2016) and the media have reported on environmental degradation arising from industrialism as stated in the following excerpt:

'*Environmental experts alarmed by industrial pollution in Douala' (*Pefok, 2007*)*

These environmental postulations always call for industries to improve their environmental performance.

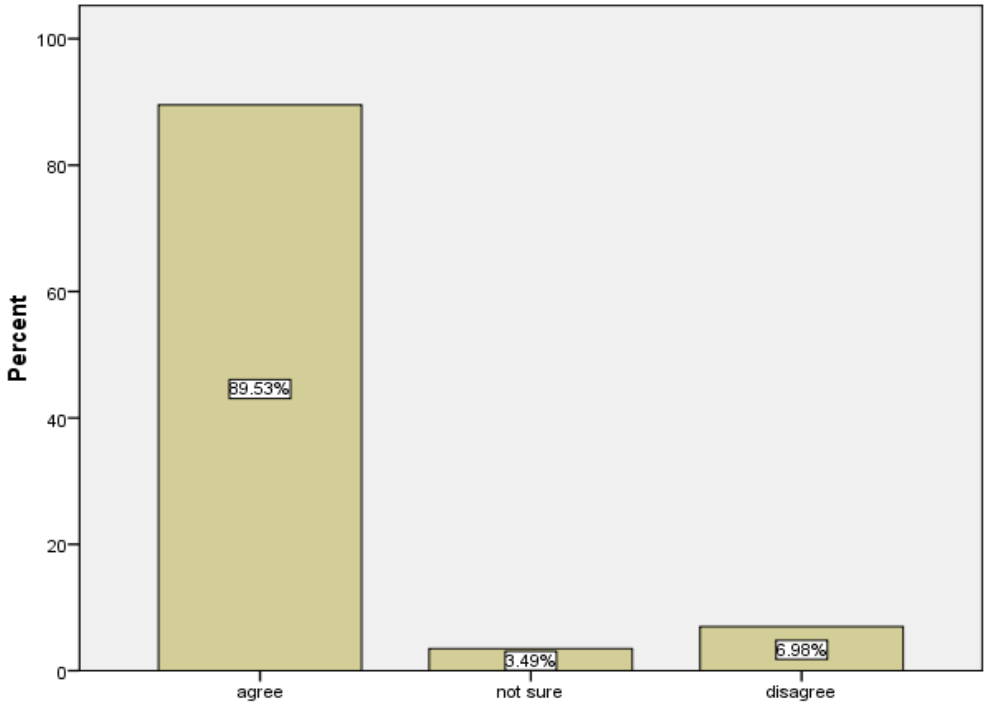

Figure 4.3: The activities of the mechanical industries depletes the ozone layer.
Source: Field survey, 2017

Figure 4.3 reveals that, 77 respondents representing 89.5% agreed that the activities of the mechanical industries depletes the ozone layer, six (6) respondents representing 7% disagreed while three (3) respondents representing 3.5% were not sure. This finding is in agreement with Keoleian and Menerey (2014), they asserted that ultimately environmental impacts, as indicated by resource depletion and pollution, are a function of design. Product P2 practices are starting to demonstrate that, when used creatively, a preventive life cycle approach can identify the priorities practically and define the trade-offs required for meaningful improvements that benefit the environment. For instance, enterprises in the foam and refrigeration manufacturing sector benefited from technology transfer to upgrade factory production equipment financed under the framework of the Montreal Protocol to eliminate ozone depleting substances (CFC 11 and 12). This was accompanied by capacity building program of the personnel. Within the implementation of the _Large

Marine Ecosystem of the Gulf of Guinea' Project, Cameroon benefited through transfer of equipment and know-how in the quantification and control of industrial effluents (UNIDO, 2012).

4.2 Broad-based Possibilities for Environmental Improvements Arising from Materials Selection and Product Design.

Table 4.3 reveal the kind of improvements that has been done to manage waste water.

Table 4.3: The kind of improvements that has been done to manage waste water

The kind of improvements that has been done to manage waste water	Frequency	Percentage
Control system	58	67.4
Automatic	15	17.4
Manual	13	15.1
Total	**86**	**100**

Source: Field survey, 2017

Table 4.3 indicates that 58 respondents representing 67.4% said that the kind of improvements that has been done to manage waste water is control system, 15 respondents representing 17.4% said that the kind of improvements that has been done to manage waste water is automatic while 13 respondents representing 15.1% said that the kind of improvements that has been done to manage waste water is manual. As one considers the concept and practice of pollution prevention, one soon realizes that it is the decision-making behind processes and products that is the foundation of the most important changes. Design, where decisions and choices are made before they are acted upon, is the logical starting point for product P2. This is true of other areas of preventive engineering but for pollution prevention it has been considered to the point where a number of approaches and projects have been developed. This agrees with Lam et al., (2015), they opined that the preventive

measures aim at prevention/minimization of waste production, pollution and/or environmental degradation at source. On the other hand, reactive or curative measures target the treatment of unavoidable environmental problems attributed to specific processes of an industrial system after pollution has already taken place. This involves the mitigation of pollution, waste and/or environmental degradation using end-of-pipe waste treatment technologies and disposal in an environmentally friendly manner. But it is important to integrate these approaches in environmental policy development for the sake of efficiency and effectiveness.

Table 4.4: The source of knowledge in relation to improvement of the environmental Performance of the firm

The source of environmental improvement knowledge	Frequency	Percent
Consultancy	27	31.4
Supplier	20	23.3
University/Research institute	18	20.9
Government agency	10	11.6
NGOs	7	8.1
International donor agency	4	4.7
Total	86	100.0

Source: Field survey, 2017

Table 4.4 indicates that 27 respondents representing 31.4% affirmed that the source of knowledge in relation to improvement of the environmental Performance of the firm is private consultancy, 20 respondents representing 23.3% said that the source of knowledge in relation to improvement of the environmental Performance of the firm is the firms supplier, 18 respondents representing 20.9% said that their source of environmental improvement knowledge is University/Research institute, 10 respondents representing 11.6% said that government agency is their source of environmental improvement knowledge, seven (7) respondents representing 8.1% had their knowledge from NGOs while four (4) respondents representing 4.7% had their

knowledge from international donor agencies. These agencies provide pollution prevention strategies for environmental improvement and protection. These findings agree with Porter, (2010), who opined that a pollution prevention strategy promotes economic stability and other business goals because the costs and hazards of managing pollution and dealing with regulations are reduced or avoided all together. This is especially true for unforeseen future costs arising from new regulation, as well as the immediate costs facing a polluter. According to Hansen et al. (2012) knowledge network is composed of suppliers, customers, environmental authorities, technological service centres, knowledge research institutes and universities etc. The claim here is that it is through these networks that actors and institutions reflect, perceive and communicate environmental knowledge capable of ecologically restructuring of an industrial system.

Table 4.5: The kind of knowledge the company need in order to become more innovative

The kind of knowledge the company need in order to become more innovative	Frequency	Percent
Technical assistance	44	51.2
Consultancy	13	15.1
Training	22	25.6
Demonstration	7	8.1
Total	**86**	**100.0**

Source: Field survey, 2017

Table 4.5 shows that 44 respondents representing 51.2% said that the kind of knowledge the company need in order to become more innovative is technical assistance, 22 respondents representing 25.6% said that their mechanical firm need adequate training to become innovative and environmental conscious, 13 respondents representing 15.1% said that they need consultancy services to become more innovative while seven (7) respondents representing 8.1% said that they need

practical demonstration training to become innovative. This agrees with Hirschhorn (2008), who said that an effective prevention strategy is fully integrated into the day-today engineering and management of a firm and thus encourages technological innovation and development.

New practices that help organizations to avoid or reduce environmental negative impacts can be considered a form of environmental innovation (Renings, 2010). It is reported in the literature that a firm‘s decision to adopt environmental management practices is complex and affects business decision-making and the overall activity of a company (Halila, 2007). According to Gottlieb et al. (2015), many firms prefer pollution control rather than prevention in order to address pollution outside of the production process.

Table 4.6 Advantages of applying cleaner production

Why does the factory apply cleaner production?	**Frequency**	**Percent**
Increase production efficiency	20	23.3
Enhance product quality	24	27.9
Reduce cost of production	18	20.9
Increase competitiveness	14	16.3
Comply with the effluent standards	10	11.6
Total	86	100

Source: Field survey, 2017

Table 4.6 shows that 24 respondents representing 27.9% said that the advantages of applying cleaner production is to increase product quality, 20 respondents representing 23.3% said that cleaner production increase production efficiency, 18 respondents representing 20.9% said that cleaner production reduce cost of production, 14 respondents representing 16.3% said that cleaner production increase competitiveness, while 10 respondents representing 11.6% said that cleaner production helps the company to comply the effluent standards. Improving

production procedures includes better housekeeping, inventory control and material handling — practices for effective management and good engineering which, besides being common sense for other reasons, can dramatically reduce waste and improve efficiencies.

4.3 The Challenges Faced by Mechanical Industries in Their Attempt to Protect the Environment.

Table 4.7 shows the challenges faced by mechanical industries in their attempt to protect the environment.

Table 4.7: The biggest obstacles to improve the environmental performance of the factory

The obstacles that hinder the improvement of environmental performance of the factory	Frequency	Percent (%)
Lack of awareness of environmental problems and potential solutions	17	19.8
Lack of environmental technologies (clean technologies applications)	25	29.1
Lack of incentives in the external environment of industrial firms to engage into the improvement of the environmental performance	23	26.7
Ineffective functioning of the institutional infrastructure that serves to assist industries in improving technology	21	24.4
Total	**86**	**100**

Source: Field survey, 2017

Table 4.7 depicts that 25 respondents representing 29.1% said that lack of environmental technologies (clean technologies applications) affects the improvement of the environmental performance of the factory, 23 respondents representing 26.7% said that lack of incentives in the external environment of industrial firms to engage into the improvement of the environmental performance affect the improvement of the environmental performance, 21 respondents representing 24.4% said that in effective functioning of the institutional infrastructure that serves to assist industries

in improving technology affect the environmental performance, while 17 respondents representing 19.8% lack of awareness of environmental problems and potential solutions affect the firms environmental performance. This findings disagrees with Jänicke, (2007), who claims that available knowledge about threats and options, environmental consciousness constitute an immediate and crucial resource for environmental actors since lack of knowledge translates to no (noticeable) environmental problem, no public awareness and definitely a stalled policy process. Thus capacity in environmental protection is associated with improvements in informational and communicative capacities of the stakeholders of an enterprise.

Table 4.8 Complying with environmental laws

Complying with environmental laws	Frequency	Percent (%)
Control of emission	23	26.7
Self–control	20	23.3
Visual inspections	28	32.6
Reaction when problem occur	15	17.4
Total	86	100.0

Source: Field survey, 2017

Table 4.8 shows that 28 respondents representing 32.6% said that the mechanical industry comply with environmental laws regarding periodic visual inspections of the mechanical industries, 23 respondents representing 26.7% said that the mechanical industry comply with environmental laws regarding control of emissions, 20 respondents representing 23.3% affirmed that the mechanical industry comply with environmental laws regarding self control while 15 respondents representing 17.4% said that the firm reacts when problem occur. This means that to comply with environmental laws and regulations, training and development is essential. To become certified, or registered, environmental training needs must be

identified and the employees shall have received appropriate training. Each company needs to analyze which employees can have a significant impact on the environment in their work; that is, employees who may affect the significant environmental aspects to a noteworthy extent.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND ECOMMENDATIONS

5.0 Introduction

This chapter briefly talks about all the pages i.e from chapter one to chapter four. Its servers as a summary of whole work, findings, conclusion and recommendations and areas where the researcher has need suggestions.

5.1 Summary

The main purpose of the study is to investigate the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality. This study employed case study design. The researcher used quantitative research approach. The population for this study was the workers of the Twifo oil plantation in the Twifo Atti-Morkwa Municipality. The entire population for this study was 123. Random sampling method was used to select 92 respondents for the study. Questionnaires were the main instrument used to gather primary data. The data collected was first edited to check contradictions and ensure consistency. The statistical package for social sciences (SPSS) Version 18 was used to analyse data. The main statistical technique employed was percentages; tables were used to explain certain findings. Percentages of the Respondents and their respective views on some important issues. This was used to discuss the collected data.

5.2 Key Findings of the Study

5.2.1 The Impact of Mechanical Industries on the Environment

The study shows that 65 respondents representing 75.6% agreed that the water bodies are destroyed as a results of the activities of the mechanical industries. Moreover, 66 respondents representing 76.7% agreed that the air is sometimes

polluted as a results of the activities of the mechanical industries. Also, 73 respondents representing 84.9% agreed that the activities of the mechanical industries produce green house gases like carbon dioxide, chlorofluorocarbons, in their manufacturing process. Furthermore, 77 respondents representing 89.5% agreed that the activities of the mechanical industries depletes the ozone layer. The study shows that 75 respondents representing 87.2% agreed that Environmental Management Systems are driven by pollution reduction, protection of human health and safety of workers. The study results indicate that 75 respondents representing 87.2% agreed that the major constrains to EMS adoption were financial, insufficient knowledge and shortage of skilled labour. Moreover, 68 respondents representing 79.1% agreed that the activities of the mechanical industries creates environmental degradation arising from industrialism.

5.2.2 Broad-based possibilities for environmental improvements arising from materials selection and product design.

The study indicates that 58 respondents representing 67.4% said that the kind of improvements that has been done to manage waste water is control system, 15 respondents representing 17.4% said that the kind of improvements that has been done to manage waste water is automatic while 13 respondents representing 15.1% said that the kind of improvements that has been done to manage waste water is manual. To add more, 27 respondents representing 31.4% affirmed that the source of knowledge in relation to improvement of the environmental Performance of the firm is private consultancy, 20 respondents representing 23.3% said that the source of knowledge in relation to improvement of the environmental Performance of the firm is the firms supplier, 18 respondents representing 20.9% said that their source of

environmental improvement knowledge is University/Research institute, 10 respondents representing 11.6% said that government agency is their source of environmental improvement knowledge, seven (7) respondents representing 8.1% had their knowledge from NGOs while 4 respondents representing 4.7% had their knowledge from international donor agencies.

Moreover, 44 respondents representing 51.2% said that the kind of knowledge the company need in order to become more innovative is technical assistance, 22 respondents representing 25.6% said that their mechanical firm need adequate training to become innovative and environmental conscious, 13 respondents representing 15.1% said that they need consultancy services to become more innovative while 7 respondents representing 8.1% said that they need practical demonstration training to become innovative. The study shows that 24 respondents representing 27.9% said that the advantages of applying cleaner production is to increase product quality, 20 respondents representing 23.3% said that cleaner production increase production efficiency, 18 respondents representing 20.9% said that cleaner production reduce cost of production, 14 respondents representing 16.3% said that cleaner production increase competitiveness, while 10 respondents representing 11.6% said that cleaner production helps the company to comply the effluent standards.

5.2.3 The challenges faced by mechanical industries in their attempt to protect the environment.

The study reveals 25 respondents representing 29.1% said that lack of environmental technologies (clean technologies applications) affects the improvement of the environmental performance of the factory, 23 respondents representing 26.7%

said that lack of incentives in the external environment of industrial firms to engage into the improvement of the environmental performance affect the improvement of the environmental performance, 21 respondents representing 24.4% said that ineffective functioning of the institutional infrastructure that serves to assist industries in improving technology affect the environmental performance, while 17 respondents representing 19.8% lack of awareness of environmental problems and potential solutions affect the firms environmental performance. Moreover, 28 respondents representing 32.6% said that the mechanical industry comply with environmental laws regarding periodic visual inspections of the mechanical industries, 23 respondents representing 26.7% said that the mechanical industry comply with environmental laws regarding control of emissions, 20 respondents representing 23.3% affirmed that the mechanical industry comply with environmental laws regarding self control while 15 respondents representing 17.4% said that the firm reacts when problem occur.

5.3 Conclusions

The first objective of the study was to investigate the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality. It can be concluded that as a results of the activities of the mechanical industries the water bodies are destroyed, the air is sometimes polluted as a results of the activities of the mechanical industries, the activities of the mechanical industries produce green house gases like carbon dioxide, chlorofluorocarbons, in their manufacturing process, the activities of the mechanical industries depletes the ozone layer, Environmental Management Systems are driven by pollution reduction, protection of human health and safety of workers, the major constrains to EMS adoption were financial,

insufficient knowledge and shortage of skilled labour, the mechanical industries creates environmental degradation arising from industrialism. Therefore, the environmental management agencies should keep the activities of the mechanical industries in check in order to comply with the environmental protection rules and regulations.

The second objective of the study was to consider broad-based possibilities for environmental improvements arising from materials selection and product design. The study concluded that the kind of improvements that has been done to manage waste water are control system, automatic system and manual system. Moreover, the source of knowledge in relation to improvement of the environmental Performance of the firm are private consultancy, the firms supplier, University/Research institute, government agency, NGOs and international donor agencies. Furthermore, the kind of knowledge the company need in order to become more innovative are technical assistance, adequate training to become innovative and environmental conscious, consultancy services to become more innovative and practical demonstration training to become innovative. To add more, the advantages of applying cleaner production are to increase product quality, increase production efficiency, reduce cost of production, increase competitiveness, and helps the company to comply the effluent standards.

The third objective of the study was to identify the challenges faced by mechanical industries in their attempt to protect the environment. The study results concluded that lack of environmental technologies (clean technologies applications) affected the improvement of the environmental performance of the factory, lack of incentives in the external environment of industrial firms to engage into the improvement of the environmental performance affect ed the improvement of the

environmental performance, ineffective functioning of the institutional infrastructure that serves to assist industries in improving technology affect the environmental performance, and lack of awareness of environmental problems and potential solutions affect the firms environmental performance. Moreover, the mechanical industries complied with environmental laws regarding periodic visual inspections of the mechanical industries, the mechanical industry comply with environmental laws regarding control of emissions, the mechanical industry comply with environmental laws regarding self control and the firm is responsive to problems that occur in the external environment to improve environmental safety.

5.4 Recommendations

According to the conclusions of the study, the researcher recommended that;

1. The environmental protection agencies and non-governmental organisations (NGOs) should continue to monitor the activities of the mechanical industries in order to comply with the environmental protection rules and regulations and ensure the safety of the environment.
2. The Ministry of Energy through the District Assembly should organise periodic seminars, conferences, training programmes to educate the operators of the mechanical industries regarding the dangers associated with environmental degradation.
2. The environmental protection agencies and NGOs should periodically inspect the activities and the physical sites of the mechanical industries and ensure that they comply with environmental laws and regulations.

5.5 Suggestions for Further Studies

Based on the recommendations of the study, the researcher suggested that a similar study should be conducted to monitor the activities of the mechanical industries in order to comply with the environmental protection rules and regulations and ensure the safety of the environment, using the mechanical industries in the Central Region as a case study.

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APPENDIX A

Questionnaires for the Respondents

The researcher is a Post graduate student of University of Education Winneba, Kumasi Campus conducting a piece of research on the impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality. I respectively request that you form part of this research by completing the attached questionnaire. Anonymity and non-traceability are assured. It is my fervent hope that you participate in the study. May I thank you for your valuable cooperation.

The sections 1: Demographic Information of the Respondents

Please tick [√] in the box where appropriate

1. What is your Gender? Please tick [√]

   [ ] Male

   [ ] Female

2. What is the age category you belong? Please tick [√]

   [ ] Below 25 years

   [ ] 26-35 years

   [ ] 36-45 years

   [ ] 46-55 years

   [ ] 56-65 years

   [ ] More than 66 years

3. What is your highest level of educational qualification?

   [ ] Senior High School Certificate

   [ ] Higher National Diploma (HND)

   [ ] Bachelor‘s degree

[ ] Master's degree

[ ] PhD

Other (please state)……

4. How long have you been a worker of this firm?

[ ] 1-5 years

[ ] 5-10 years

[ ] 10-15 years

[ ] 15-20 years

[ ] 20 years and above

5. Is there currently an environmental protection plan in place? Please tick [√] in the box where appropriate

[ ] Yes

[ ] No

[ ] In progress

Section B: The impact of mechanical industries on the environment in Twifu Atti-Morkwa Municipality. Please tick [√] in the box where appropriate

To what extent do you agree on the following impacts of mechanical industries on the environment in Twifo Atti-Morkwa Municipality? Please rate using a scale of 1-5 where 1 represents strongly disagree, 2 represent disagree, 3 represents uncertain, 4 represents agree, 5 represents strongly agree.

The Impact of Mechanical Industries on the Environment	1	2	3	4	5
6. The water bodies are destroyed as a results of the activities of the mechanical industries					
7. The air is sometimes polluted as a results of the activities of the mechanical industries					
8. The activities of the mechanical industries produce green house gases like carbon dioxide, chlorofluorocarbons, in their manufacturing process					
9. The activities of the mechanical industries depletes the ozone layer.					
10. Environmental Management Systems are driven by pollution reduction, protection of human health and safety of workers.					
11. The major constrains to EMS adoption were financial, insufficient knowledge and shortage of skilled labour.					
12. The activities of the mechanical industries creates environmental degradation arising from industrialism.					

Section C: Broad-based possibilities for environmental improvements arising from materials selection and product design.

13. What kind of improvements has been done to manage waste water? Please tick [√] in the box where appropriate

    Control system [ ] Is it Automatic? [ ] Is it Manual [ ] Other (Please specify) …….....

14. What is your source of knowledge in relation to improvement of the environmental Performance of the firm? Please tick [√] in the box where appropriate

    Consultancy [ ] Supplier [ ] University/Research institute [ ] Government agency [ ] NGOs [ ] International donor agency [ ]

    Other (Please specify) …….……

15. What kind of knowledge does the company need in order to become more innovative?

    Technical assistance [ ] Consultancy [ ] Training [ ] Demonstration [ ]

16. Why does the factory apply cleaner production? Please tick [√] in the box where appropriate

    Increase production efficiency [ ] Enhance product quality [ ]

    Reduce cost of production [ ] Increase competitiveness [ ]

    Comply with the effluent standards [ ]

17. What is the incentive for company to apply the clean technologies?

    Clean technology [ ] Good housekeeping [ ] In-plant reuse/recycle [ ]

    Process modification [ ]

Section D: The challenges faced by mechanical industries in their attempt to protect the environment.

18. What have been the biggest obstacles to improve the environmental performance of the factory? Please tick [√] in the box where appropriate

    Lack of awareness of environmental problems and potential solutions [ ]

    Lack of environmental technologies (clean technologies applications) [ ]

    Lack of incentives in the external environment of industrial firms to engage into the improvement of the environmental performance [ ]

    Ineffective functioning of the institutional infrastructure that serves to assist industries in improving technology [ ]

19. Which environmental laws must the company comply with? Please tick [√] in the box where appropriate

    Control of emission [ ] Self–control [ ] Visual inspections [ ] Reaction when problem occur [ ] Other (please specify) ……