NIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION-KUMASI

THE IMPACT OF IN-EFFICIENT DIAGNOSIS OF VEHICLES BY MECHANICS ON THE ENVIRONMENT

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ISSIFU IMORO

A Dissertation in the Department of MECHANICAL TECHNOLOGY, Faculty of TECHNICAL EDUCATION submitted to the School of Research and Graduate Studies, University of Education, Winneba in partial fulfillment of the requirements for the award of the Master of Technology Education (Mechanical) Degree

AUGUST, 2013

DECLARATION

CANDIDATE'S DECLARATION

I, ISSIFU IMORO, declare that this Dissertation, with the exception of quotations and references contained in published works, which have all been identified and duly acknowledged, is entirely my own 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 of this thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University of Education, Winneba.

Supervisor: Mr. STEPHEN K. AMOAKOHENE

Signature:……

Date:……

ACKNOWLEDGEMENT

I would first like to express my profound gratitude to my supervisor, Mr. Stephen K. Amoakohene who promptly responded to my calls and offered suggestions to me during his supervisory role into this study.

Secondly, to all the Lecturers through whose hands I passed during this programme in this University not forgetting my classmates.

Lastly, my gratitude goes to Alhaji Mustapha A. El-Sannogho of Automotive Engineering Department of Tamale Polytechnic who assisted me to accomplish this project and to all the respondents at Tamale Metropolis for their wonderful cooperation, especially the Automobile workshop owners for their patience and acceptance.

DEDICATION

This study is dedicated to my lovely wife- Aliatu Ibrahim, children; Naidatu Chempang , Abdul-Muyasir Wun-Nam , Saabit Tipagya, my mother, my late father and my wonderful friends for their prayers and support in my education.

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ABSTRACT

The aim of the study is to assess the general knowledge of Technicians and Mechanics in the Automobile repair sector in Diagnosing Electronics managed Vehicles in the Tamale Metropolis .The research questions were based on the levels of understanding of the systems by Mechanics in Diagnosing Electronics managed Vehicles in order to reduce its effects on the Environment. The descriptive survey design was used for the study. The sample of 60 comprised of Managers and Mechanics, randomly selected from the Tamale Metropolis. The data was analyzed using Statistical Package for Social Sciences (SPSS v16).The study revealed that, majority of the Mechanics and the Workshop Managers had formal Education, percentages (n=28, 46.7%) and lack modern diagnostic equipments and training on how to use the Diagnostic Equipments and the Effects of pollution as result of their activities on the Environment. Majority (n39, 65%) agreed that the Government and the Trade Union should organize this training for them. Based on the findings, it was recommended that, Mechanics who are trainable need skill training periodically to help them to upgrade their skills to reduce this canker.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Over the years, much is happening internationally to minimized vehicle pollution. This cannot be achieved without efficient vehicle inspection and diagnosis by vehicle mechanics in the automobile repair industry. Since accurate diagnosis of a vehicle leads to accurate repair, it is important to sensitize vehicle mechanics in the industry the need to maintain very good diagnostic practice minimize pollution as a result of in-efficient repairs.

Snap-on (2011) reported that, there are four possible sources of atmospheric pollution from the automobile. Without emission controls, a carburetor and fuel tank emit fuel vapors, the crankcase emits blowby gases and fuel vapors, and the tailpipe emits exhaust gases that contain air pollutants. These pollutants are unburned hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NOx). Cars and trucks cause a lot of air the pollution in the world today, and contribute a lot to the most common and dangerous air pollutants. Stephen J. Gislason (2011) explained that mothers in highly car polluted areas have smaller babies which are not good for their health. This is according to The Journal of Environmental Health Perspectives. – According to Government of Scotland data, up to 3,000 people die from car induced air pollution. This is in contrast to 190 killed per year in car crashes. - About 80 people per DAY are killed in the USA from car induced air pollution...or - Air Particulate

Matter pollution kills an average of 40,000 per year in the U.S. and up to some 200,000 in Europe.

According to Gislason (2011) driving a car is the most air polluting act an average citizen commits. Air pollution is not a good idea for a variety of reasons, large and small. The right ideas for remediation of environmental degradations involve unselfish and compassionate behaviour, a scarce commodity. The right ideas involve long-term planning, conservation and a deep commitment to preserving the natural world. Without a healthy natural environment, there will be few or no healthy humans

Fact is that, over 20 years ago, the vehicles that enter the international automobile market, especially in the USA, must meet certain standards pertaining emission, drivability and fuel economy. Hence, there is no way a vehicle of such standard can be without one or more micro- processor based computers. Also, nowadays, ever since the electronics was introduced to manage various systems in automobile vehicle, inspection and diagnosis had gone beyond the rule of thumb. Diagnosis of vehicles with electronic engine management system now has become so sophisticated; demanding the use of micro-processor based tools and equipments, as well as technicians commensurate with the right level of training/skills.

The automobile repair industries in the Tamale metropolis consist of not only garages with the right caliber of sophistication such as Japan Motors, Toyota Ghana etc in terms of equipment and human resources, but also with so called roadside mechanics. Even without statistics available this study wants to believe that the roadside mechanics, which are ill-equipped, outnumbered the likes of Japan motors

and Co. This implies that they must be occupying a key position in the automobile repair industry.

1.2 Statement of the problem

The large majority of today's cars and trucks use internal combustion engines as power plants that burn gasoline or other fossil fuels. The process of burning gasoline to power cars and trucks contributes to air pollution by releasing a variety of emissions into the atmosphere. Emission that is released directly into the atmosphere from the tailpipes of cars and trucks are the primary source of vehicular pollution. Motor vehicles and repair garages also pollute the Environment during the process of servicing and repairs of vehicles. As results of the above problems associated with exhaust pollution, it has become necessary to ensure that proper diagnosis carried out in all service garages. There has been an increase in traffic population in the Tamale Metropolis currently and these have contributed to the vehicular pollution in the Metropolis and the mechanics and garage owners do not have the requisite knowledge and skills to use some of the modern diagnostic and repair equipments mandated by the automobile industries.

This requires formal training for old garage owners and mechanics to enable them handle after sales services of these vehicles effectively. High illiteracy level of the “roadside mechanics” makes it difficult for them to understand the functions of the various diagnostic and repair system. They also find it difficult to read and understand service and repair manuals and this has great drawback in their service and repair works to meet transport legislation condition and satisfy environmental safety.

1.3 Main Objective

The general objective of the study is to access the vehicle diagnostics and repairs capabilities of vehicle mechanics, technician, garages and garage owners and the health and environmental hazards associated with that sector and to find out possible ways of minimize exhaust pollution.

1.4 The specific objectives of the study are to;

Provide recommendations to the environmental protection agencies and the Ghana standard board;

- access constraints militating against efficient diagnosis of motor vehicle.
- help improve the use of diagnostic equipments by vehicle service and repair garages.
- Encourage the vehicle repair technician, mechanics, garages and garage owners to participate fully in the training and use of diagnostic equipments.
- reduce vehicle breakdown as a result of improve knowledge in the management systems.
- educate vehicle repair technician, mechanics, garages and garage owners the need to carryout pollution free maintenance.

1.5 Purpose of the Study

Vehicle inspection and diagnosis is a mandatory exercise in the automobile repair industry. An accurate diagnosis of a vehicle leads to accurate repairs. Since the electronics was introduced to manage various systems in automobile vehicle, inspection and diagnosis had gone beyond the rule of thumb. Diagnosis of vehicles

with electronic engine management system now has become so sophisticated; demanding the use of micro-processor based tools and equipments, as well as technicians to commensurate with the right level of training/skills.

The automobile repair industries in the Tamale metropolis consist of garages with the right caliber of staff and sophistication in equipments such as Japan Motors, Toyota Ghana, Mechanical Lloyd and the so called roadside etc and the so called roadside mechanics. They constitute percentage of human resource in the service /repair work of motor vehicle in the metropolis. Although they contribute to the development of the industry and the economy of the region in particular, they will require formal training and education to improve their proficiency.

Ghana is now a middle income level country. This has attracted a lot of investors into the country in the area of manufacturing services, transport and agriculture.

Increase number of vehicles in the future has become inevitable and so be exhaust emission and these requires some level of skill man power to able to handle modern equipments for repairs/service work in the metropolis. The need for critical investigation and the steps to mitigate the automobile exhaust emission has does become necessary. The study also looks into the human, the technical and the environment situation and condition that degrade the environment and causes health hazards against the safety of human beings. It is against this background that the study is being conducted. Although, a lot has being said about the exhaust emissions and environmental pollution. The research also sick's to bring to bare other factors responsible for the in-efficient diagnosis of vehicles by mechanics on environmental

pollution, especially in the northern region of Ghana and to identify them and offer suggestion for its mitigation.

1.7 The research questions for study are:

1. How do the knowledge of the systems aid in speedy and efficient diagnostics.
2. To what extend does improper diagnostics causes exhaust pollution problems?
3. How do proper diagnostic equipments leads to efficient and pollution free exhaust.
4. How relevant is emission control devices in the vehicle exhaust system.

1.8 Significance of the study

Vehicles exhaust pollution has become a global canker due to the increasing number of vehicles produced annually by the Automobile production companies and these vehicles need to be maintained according to the usage levels in order to ensure that the vehicles are operating effectively and efficiently to reduce at the end of combustion, hydrocarbons, carbon monoxide, nitrogen oxides and other poisonous gases which affect human health and the environment as a whole.

In the Tamale metropolis of Northern Region of Ghana, the state agencies such as the environmental protection agency, the Regional factory Inspectorate Division and the Vehicle and Driver License Authority are all working towards controlling Environmental safety.

This, however, takes an in-depth and specific look at the Environmental pollution as a consequence of Automobile Exhaust emission. Automobile Exhaust Emission such as carbon monoxide(CO), hydrocarbon (HC), nitrogen oxide (NOx), are dangerous substance not only health hazards to the community they work , but a Global catastrophe such as the depletion of the ozone layer.

Although Tamale is far from the coast to experience TSUNAMI and the likes, its Global impart will affect Ghana as a developing country in the West African sub-region.

As a result of the above problems associated with exhaust pollution, it has become necessary to ensure that proper diagnostic standard is maintain by the regulatory authorities in eliminating the poisonous gases being emitted to the environment to the bearers' minimum.

1.9 Scope of the study

The sample that will be taken, the researcher strongly believes that it will help the researcher meet the purpose of the study. The anticipation is to reach most of the Auto mechanics as much as possible to make it a reality, not withstanding some few possible problems and hindrances that are likely to encounter. Even though every effort will be made to administer the questionnaires to the various samples that would be selected as well as having the illiterate amongst them to be interviewed. Even though many of them may have ill feeling about it and may pretend not to understand the questions.

Notwithstanding all these limitations, the information that will be obtained is believed to be reliable, as it will come from a good percentage of the population sample that will be used for the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

In this chapter, the writer tries to review the related literature from published and unpublished books, internet, journals and other relevant information on the topic.

The following are the main headings discussed:

- knowledge of the systems by Mechanics
- improper diagnostics on exhaust pollution
- Diagnostic equipment
- Effects of exhaust emissions
- emission control measures in vehicles

2.1 Knowledge of the systems by Mechanics

The importance of education cannot be over-emphasized as it is needed in every sphere of human endeavour. Mechanics in the automotive repair sector therefore should, at least, have some knowledge of the systems, tools, equipment of the sector and the materials and processes they use. They should be able to read the manual instructions of the vehicles and diagnostic equipment that they use and this knowledge is gained through formal education.

AutoTap (2011), only qualified, trained technicians equipped with the appropriate diagnostic and repair equipment should conduct OBD related service. With

the population of modern technology cars growing, all dealerships and independent repair shops should have qualified personnel for this service. Vehicle owners should ask at their service facility if the technicians have received proper training, and have access to the necessary equipment to properly service OBD equipped vehicles. (AutoTap ,2011). OBD II, Diagnostic Scanner. Chris Korleski (2007) indicated that, Technicians who service motor vehicles must use U.S. EPA approved equipment for refrigerant recovery and recycling. Recover/recycle equipment cleans the refrigerant so that contaminants like oil, air and moisture reach acceptably low levels. A list of approved recovery and recycling equipment is available from U.S. EPA's ozone hotline and Web site. Service shops performing recovery/recycle operations must certify to U.S. EPA that they own approved equipment. Chris Korleski (2007). (OCAPP) hold that Environmental Compliance Guide for Auto Repair Shops. Office of Compliance Assistance and Pollution Prevention.

Engine manufacturers face many challenges in providing engines to meet the needs of customers, Environmental Protection Agency (EPA), the California Air Resources Board (ARB), other government agencies, and their own businesses. During the past five years, engine manufacturers have poured huge resources into meeting stringent new federal and California emissions standards that began in 2007 and that will be fully realized by 2010. The new emission standards will reduce engine emissions by more than 90% and those reductions will come through using improved engine design, advanced after market inspection and maintenance programmes.

OBD is technically complex, and this means sophisticated new systems are placed on engines and vehicles. Regulating how manufacturers use OBD to monitor

their engine emission control adds more complexities and new challenges to produce engines that are compliant with 2010 and later standards and all engines manufacturers will need to devote substantial time and effort to meeting the new rule, but those without experience will have special challenges to overcome such as basic understanding of OBD terminology.

National Automobile Dealers Association, US (NADA, 2005).

Derek Newbold and Allan Bonnick. (2005) When a number of computer controlled systems on a vehicle are required to communicate with each other, as happens with cruise control, traction control, diagnostics and other systems, the computers are connected to each other for communication purposes. Linking computers together, for communications purposes, is called networking and the lines (wires) that are used for this purpose are known as buses. (Allan Bonnick and Derek Newbold, 2005, P. 238)

Tom Denton (2006) who explains that, in 1960, The Motor Vehicle Pollution Control Board was established with a mandate to certify devices proposed to be fitted on cars for sale in California. In addition, The Federal Motor Vehicle Act of 1960 was enacted, requiring Federal research to combat motor vehicle engine pollution. This lead to vehicle manufacturers to introduce new technologies to meet the stringent test measures. California Smog test Program aim was to identify vehicles in need of maintenance and to confirm the effectiveness of their emissions control systems. The mid-term period of emissions control legislation ended in 1988 with a key announcement, which saw the beginning of on-board diagnostics. The California Clean

Air Act was signed and adopted regulations that required that all 1994 and beyond model year cars were fitted with 'On-board Diagnostic' systems. The task of these systems is to monitor the vehicle emissions control systems performance and alert owners when there is a malfunction that results in the malfunctioning of an emissions control system or component. This development continued and expanded demanded an increasing array of sensors and actuators. The resolution of measurement, control of air/fuel ratio, actuator displacement rates and accuracy of displacement, was way beyond that which could be provided by traditional existing mechanical technologies which was provided in the form of recent advances in microprocessor technology for on-board diagnostic system monitoring. Tom Denton (2006 P. 62-63).

Carley Software (2009) explained that, Malfunction Indicator Lamp (MIL) or CHECK ENGINE light as it is more commonly called, is essentially an emission warning light. If the light comes on, it means the Onboard Diagnostics II system (OBD II) has detected an emissions-related problem. OBD II is designed to turn on the MIL light if a problem occurs that may cause emissions to exceed federal limits by 150 percent. The problem has to occur more than once, and it must be significant enough to create a potential emissions problem (one serious enough to prevent a vehicle from passing an emissions test). On the other hand William H. Donald L. (1997), Also stated that Diagnostics of new generation vehicles (OBD I); The Check engine light which is actually the Malfunction Indicator Lamp (MIL) alert the driver when a problem occurs in the engine control system. Depending on the nature of the problem, check Engine Light may come on and go off, remain on continuously or flash. Some intermittent problems will make the Check Engine Light comes on only while the fault

is occurring. When the problem goes away, the Check Engine Light goes off .Other type of problems will turn the Check Engine Light on, and it will remain on until the fault is diagnosed and repaired. William H. Donald L. (1997).

Alfredas Rimkus(2007) indicates that, Automotive diagnostics is one of the main subjects in training car service specialists. The diagnostics subjects consist of theoretical and practical training. Various types of engine management systems work and their faults are investigated. The main equipment consists of engine simulators. The development of using micro processing technologies in automotive controls requires more sophisticated diagnostics equipment. Most developing diagnostics equipment are systematic testers which takes the information from the electronic control unit ECU about trouble codes and display the parameters. Alfredas Rimkus (2007)

William. H and Donald L. Anglin.(1996) asserts that, malfunction indicator light in the instrument panel is used retrieved trouble codes through a series of flashes representing numbers and the second and preferred way is to connect a compatible scan tool or diagnostic computer to the vehicle diagnostic computer to the vehicle diagnostic connector or data-link connector (DLC). The illustration above shows how CHECK ENGINE light flashes on General Motors vehicle is use to retrieve diagnostic trouble codes. The flashes indicate stored diagnostic trouble codes. **For example, a code 12** consists of one flash followed by a pause and then two more flashes. (William. H and Donald L. Anglin., 1996. p. 326). On the other hand, Allan Bonnick (2001) found that, as a result of the different technology used in automotive computer

controlled systems; it is possible to find a number of different methods of accessing DTCs. Three methods are in general use.

1. Displaying the code as flashes on a dashboard indicator lamp.

2. Connecting an LED or test lamp externally and observing the number of flashes and pauses.

3. Connecting a code reading machine, and/or a scan tool, to the diagnostic port on the ECM. (Allan Bonnick 2001, P. 66)

Setting trouble codes in older vehicles (OBD I), those made before 1996, disconnecting the computer's power source or disconnecting a battery cable erases fault codes and turn off the Check Engine Light, at least temporarily. If the problem persists, the code will reset and the Check Engine Light will come on. Many newer vehicles, you do NOT have to disconnect the battery because doing so can wipe out the computer's memory settings. This may affect the operation of the transmission, climate control system and other function doing so can wipe out the computer's memory settings. This may affect the operation of the transmission, climate control system and other functions. In 1996 and newer vehicles, a scan tool or code reader must be used to erase codes and turn the Check Engine Light off. (William H. Donald L. (1997, .p.333)

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problem has to occur more than once, and it must be significant enough to create a potential emissions problem or serious enough to prevent a vehicle from passing an emissions test. On the other hand, Carley Software (2009), indicated that, the Malfunction Indicator Lamp (MIL) or CHECK ENGINE light as it is more commonly called, is essentially an emission warning light. If the light comes on, it means the Onboard Diagnostics II system (OBD II) has detected an emissions-related problem. CarleySoftware (2009),

According to Allan W. M. Bonnick (2001) when the diagnostic check is completed the 'service wire' must be removed from the 'check engine' connector and then the diagnostic code must be cancelled. After the fault has been rectified, the diagnostic code stored in the Electronic Control Unit (ECU) memory must be cancelled. In some Toyota models, this is achieved by removing the appropriate fuse for a period of 10 seconds or more, depending on the ambient temperature, with the ignition switched off. Allan W. M. Bonnick (2001, P. 69)

An Article retrieved from http://www.ertl.jpl~hirol Described the catalytic converter as after-burner. It oxidizes (burns) any residual fuel vapors unburned hydrocarbons (HC) in the exhaust. It also burns any carbon monoxide (CO) in the exhaust. The exhaust must meet federal emission standards, and if a problem exists that causes emissions to exceed the federal limits by 150%, the OBD II system is supposed to detect the fault, set a trouble code and turn on the Check Engine light. The OBD II system can't actually measure the concentration of HC or CO in the exhaust, so it compares the upstream and downstream O2 sensor readings to determine how efficient the catalyst is actually functioning in dealing with the pollutants from the exhaust. Tom Denton

(2004) found that, the Catalytic converters stringent regulations in most parts of the world have made the use of a catalytic converter almost indispensable. The three-way catalyst (TWC) is widely use by most manufacturers. It is a very simple device and looks similar to a standard exhaust box. Note that, in order to operate correctly, however, the engine must be run at correct air fuel ratio (stoichiometry) or very near to stoichiometry. Tom Denton (2006 p. 49)

Newbold and Allan Bonnick (2005) explained that, when a microcontroller (computer) is controlling the operation of an automotive system, such as engine management, it is constantly taking readings from a range of sensors. These sensor readings are compared with readings held in the operating program and if the sensor reading is within the program value in the Read Only Memory ((ROM), the microcontroller will make decisions about the required output to actuators, such as injectors. If the sensor reading is not within limits it will be read again and if it continues to be 'out of limits', a fault code will be stored in a section of Random Access Memory (RAM). Derek Newbold and Allan Bonnick. (2005 P. 238).

Tom Denton (2006) point out that, fault codes can be cleared from the ECU memory in two ways:

- using the facilities of a fault code reader (scanner) to clear the memory;

- disconnecting the battery earth lead for about two minutes (does not always work however). The first method is clearly recommended because disconnecting the battery will also 'reset' many other functions such as the radio code, the clock and even the learnt or adaptive functions in the ECUs. Tom Denton (2006, P. 18).

(Tayota sales, USA Inc.). The Electronic Control Unit (ECU) to monitor the operating conditions, utilizing information from the sensors.

2.2 Improper diagnostics on exhaust pollution

Rimkus (2007) suggested that, Automotive diagnostics is one of the main subjects in training car service specialists. The diagnostics subjects consist of theoretical and practical training. Various types of engine management systems work and their faults are investigated. The main equipment consists of engine simulators. The development of using micro processing technologies in automotive controls requires more sophisticated diagnostics equipment. Most developing diagnostics equipment are systematic testers which takes the information from the electronic control unit ECU about trouble codes and display the parameters. Mechanics are measuring engine management signal through the input connectors to the screen of the PC to see engine management signals graphics image. The signals are analyzed and that how the faults are diagnosed. (Rimkus,2007)

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Tom Denton (2006) hold that continual increase in the use of electronics within vehicles represents a major challenge for customer service and workshop Technicians and Mechanics. Modern diagnosis and information systems must cope with this challenge and manufacturers of test equipment must provide instruments that are flexible and easy to handle. Quick and reliable fault diagnosis in modern vehicles requires extensive technical knowledge, detailed vehicle information, up-to-date testing systems and the skill to be able to apply all of these. (Denton, 2006, p. 20).

Eran Sher(1998), explained that emission control technology, developed with much hard work by engineers over the past 25 years, which is very effective at reducing emissions from most cars on the road for much of their useful life, but its failure to achieve this control as small fraction of the vehicles live will offset the gains made. Our future efforts to reduce emissions must somehow deal with this reality. Eran Sher (1998, P. 15-17). T.k. Garrett (2001) indicated that, attention was first directed to atmospheric pollution in Los Angeles in 1947. Subsequently, in 1952, Dr Arie J. Haagen-Smit asserted on the basis of his research that, at least locally, it was due mainly to automotive exhaust emissions. It was subsequently said, however, that it would have cost the USA less to have moved Los Angeles than to have converted all their vehicles to reduce the emissions to the levels now required by law. Japan was close behind the USA with emission control laws, and Europe has practically caught up. Given complete combustion, each kilogram (kg) of hydrocarbon fuel when completely burnt produces mainly 3.1 kg of carbon dioxide (CO2) and 1.3 kg of H2O. Most of the undesirable exhaust emissions are produced in minute quantities (parts per million), and these are: oxides of nitrogen, (NOx), unburnt hydrocarbons (HC), carbon

monoxide (CO), carbon dioxide (CO2), lead salts, polyaromatics, soots, aldehydes ketones and nitro-olefins. Of these, only the first three are of major significance in the quantities produced. However, concentrations in general could become heavier as increasing numbers of vehicles come onto our roads. By the end of the 1980s, CO2 was beginning to cause concern, not because it is toxic but because it was suspected of facilitating the penetration of our atmosphere by ultra-violet rays emitted by the sun. Controversy has raged over lead salts, but no proof has been found that, in the quantities in which they are present in the atmosphere, they are harmful. For many years, manufacturers of catalytic converters pressed for unleaded petrol because lead deposits rapidly rendered their converters ineffective. T.k. Garrett (2001, p.516). Jean-Paul Rodrigue (2013) stated that, Emissions or smog is a generic term used to describe certain harmful gases in the exhaust. Hydrocarbons (HC), Carbon Monoxide (CO) and Oxides of Nitrogen (NOX) are usually measured in an emissions test. The state and federal government place certain limits on each of these harmful gases emitted.

On the other hand, Mike Allen (2006) said that the source of the short circuit is obvious be a wiring which is dangling under the dashboard or on the other hand, you may need to do some serious troubleshooting to find the source of the problem. A short circuit occurs when an energized conductor touches either the frame or body of the car or another wire. Shorts to ground usually will have low enough resistance to draw sufficient current to blow the fuse. If the short is to another circuit, you may see things like the dome light coming on when you hit the turn signals. You may discover a wiring harness or multiprong connector meltdown, caused by the heat liberated from a short or high-resistance connection. Moreover, not all wiring problems are shorts:

Open and intermittent connections also can cause similar problems. (Mike allen 2006). These findings also corroborate with the study by Morris Rosenthal (2011) to check for a short circuit after a blown link. Don't just replace the blown fusible link without checking if it blew due to a short circuit that is still in effect. A short circuit, by definition, is a circuit with an unexpected path to ground, meaning the electricity will return to ground without powering whatever device the circuit is intended to power. The way to test for a short circuit is to check for continuity (or low resistance) with your meter between ground and the supply line (where the +12 volts is supposed to flow) in the circuit. In order to safely test for a short circuit using convenient bare metal as ground, it's easiest to leave the ground to the battery connected and remove the positive battery connector. But make sure you keep it well away from the positive battery terminal when it's off, or cover the positive battery terminal with a plastic cap or a heavy insulating sheet. When you are sure the positive battery terminal is disconnected and isolated, you can turn the ignition key to "run" and check for a short from the other side of the blown link to the battery ground or to any bare metal spot on the car. (Morris Rosenthal 2011, p.6). Don Nisbett (2012) revealed that, as a vital part of modern cars, wiring harnesses containing thousands of assembly components connect various electronic systems, enabling them to work together. A single failure in any harness can affect the entire system. Nevertheless, to accommodate the growing demand for in-car electronics, the complexity of automotive wiring harnesses continues to grow, increasing the need to detect broken or shorted wires quickly and easily. (Don Nisbett, 2012).

Technicians who repair motor vehicles in the US, must be trained and certified by a U.S. EPA approved organization. Training must include instruction on the proper use of equipment, regulatory requirements, importance of refrigerant recovery and the effects of ozone depletion. To be certified, technicians must pass a test demonstrating their knowledge in these areas. A list of approved testing programs is available from the U.S. EPA. Office of Compliance Assistance and Pollution Prevention (OCAPP, 2007, p. 5). Mark Davidson (2013) explains that, Mass air flow sensor is used by the control module to measure the volume of air entering the engine. The control module uses this information to calculate fuel delivery. The typical Mass air flow (MAF) sensor contains a mesh screen to break up air flow and prevent debris from entering the sensor. Mark Davidson (2013. Mike allen (2006) said that the source of the short circuit is obvious be a wiring which is dangling under the dashboard. A short circuit occurs when an energized conductor touches either the frame or body of the car or another wire. Shorts to ground usually will have low enough resistance to draw sufficient current to blow the fuse. (Mike allen 2006). The finding also corroborates with the study by Morris Rosenthal (2011) that to check for a short circuit after a blown link. Don't just replace the blown fusible link without checking if it blew due to a short circuit that is still in effect. A short circuit, by definition, is a circuit with an unexpected path to ground, meaning the electricity will return to ground without powering whatever device the circuit is intended to power. Morris Rosenthal (2011, p.6). Don Nisbett (2012) study revealed that, as a vital part of modern cars, wiring harnesses containing thousands of assembly components connect various electronic systems, enabling them to work together. A single failure in any harness can affect the

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Derek Newbold and Allan Bonnick. (2005) reported that, when a number of computer controlled systems on a vehicle are required to communicate with each other, as happens with cruise control, traction control, diagnostics and other systems, the computers are connected to each other for communication purposes. Linking computers together, for communications purposes, is called networking and the lines (wires) that are used for this purpose are known as buses. (Allan Bonnick and Derek Newbold, 2005, P. 238)

Routine maintenance should include visual checks of electrical circuits and connections and also similar checks of fuel lines. Mileage based servicing will include renewal of air filters, servicing the carbon canister, inspecting and cleaning or renewing and fuel filters. Since the introduction of European On Board Diagnostics (EOBD), all emissions related functions, such as the fuel system, are constantly monitored by the engine computer (ECM). In the event of a defect in any part of the fuel system, the malfunction indicator lamp (MIL) will alert the driver and fault codes will be stored in the computer. (Derek Newbold and Allan Bonnick. 2005 P. 106)

Snap-on (2011) point out that, special diagnostic procedures, Scan tools and other special testers may be required to locate the trouble. To use diagnostic trouble codes (D T C), you must first know how to retrieve the trouble codes. You must also be able

to understand and interpret what the trouble codes mean. Furthermore, you must know which circuits are monitored by the computer and which are not is important to interpreting trouble codes. Snap-on (2011) and Tom Denton (2004) in this direction explains that, the first character of the diagnostic code relates to the system of the vehicle that generated the code:

P _ Powertrain

B _ Body

C _ Chassis

U_ Network

The next character can be either 0 or 1:

0 _ Standard (SAE) OBD code

1 _ Manufacturer's own code

The next character identifies the specific part of the system concerned. For the Powertrain systems

These are:

1 _ Fuel and air metering

2 _ Fuel and air metering, specifically injector

Circuit

3 _ Ignition system and misfire detection

4 _ Auxiliary emission controls

5 _ Vehicle speed control and idle control system

6 _ Computer output circuit

7 _ Transmission related faults

8 _ Transmission related faults

The last two numbers identify the specific fault as seen by the on-board systems.

(Denton, 2004, P. 79).

According to Steve & Lynley McAfee (2002) a misfire will cause the check engine light to flash while the misfire is occurring. A misfire that occurs in a given cylinder will also set a p030x trouble code where "x" will be the number of the cylinder that is misfiring. For example, a p0302 trouble code would tell you that cylinder number two is misfiring. The trouble code does not tell you why the cylinder is misfiring. You have to figure that out by performing other diagnostic tests. The misfire that is causing the code to set may be due to a fouled spark plug, a bad plug wire, a defective ignition coil, a clogged or dead fuel injector or a loss of compression due to a leaky exhaust valve, leaky head gasket or worn cam lobe. (Steve & Lynley McAfee, 2002, P. 3)

Dietmar Von (2011) revealed that training in fault diagnosis is continuously being revised to serve different automotive repair sectors. Car failure detection is a sequence of diagnostic processes that necessitates the deployment of expertise. The Expert System (ES) is one of the leading Artificial Intelligence (AI) techniques that have been

adopted to handle such task. Diagnosis of car faults requires high technical skills and experienced mechanics that are typically resource and experience. The systems such as Car Failure and Malfunction Diagnosis Assistance System (CFMDAS) can be highly useful in assisting mechanics for failure detection and training purposes.

Mark Davidson (2013) explains that, Mass air flow sensor is used by the control module to measure the volume of air entering the engine. The control module uses this information to calculate fuel delivery. The typical Mass air flow (MAF) sensor contains a mesh screen to break up air flow and prevent debris from entering the sensor. Mark Davidson (2013)

McAfee (2012) and lance Wright (2013) hold that Positive crankcase ventilation is a system allows fresh air through the crankcase to sweep out blowby and fuel vapour into the inlet side of the engine to prevent emission and mechanics should not ignore this important feature. The above, shows that about two-thirds of the respondents 72% responded 'True' to the fact that positive crankcase ventilation reduces vehicle exhaust emission problems. This agreed with Steven, the air enters the engine where the pollutants from the crankcase have another chance to burn to reduce emission.

Derek Newbold and Allan Bonnick, (2005, P. 101) stated that, Exhaust gas recirculation (EGR) valve play an important role in reducing emissions of Nitrogen Oxides (NOx), if combustion chamber temperatures do not rise above normal operating temperature, because it is the temperature at which NOx can be produced. Exhaust gas recirculation helps to keep combustion temperatures low by recirculating a limited amount of exhaust gas from the exhaust system, back to the induction system.

In order to provide good performance, EGR does not operate when the engine is cold or when the engine is operating at full load. Under reasonable operating conditions, it is estimated that EGR will reduce NOx emissions by approximately 30%. Derek Newbold and Allan Bonnick, (2005, P. 101)

2.3 Improper Diagnostic equipments on exhaust emission

Allan Bonnick (2001) is of the view that, Diagnostic equipment and limitations of Diagnostic Trouble Codes (DTCs), completely new set of tools and equipment is needed to deal with OBD II and possibly European on-board diagnostics (EOBD). If we take coolant sensor and consider the implications of the code that tells us that there is a low coolant temperature and consider what might be involved, we should see that reading the DTCs is often one of several steps on the path to diagnosis and repair of defects. Allan Bonnick(2001, p. 85-86).

According Tom Denton (2004, P.59) an essential tool for working on vehicle electrical and electronic systems is a good digital multimeter. (Tom Denton 2004, P.59). According to Tom Denton (2004, P.61) two types of oscilloscope are available; these are either analogue or digital. (Tom Denton 2004, P.61)

Tom Denton (2004, P.62) also, indicated that, measuring the fuel pressure in a fuel injection Engine is of great value when finding fault. The principle of the gauges is that they contain a very small tube wound in a spiral manner. As fuel under pressure is forced into a spiral tube, the tube unwinds causing the needle to move over a Graduated scale to indicate the pressure. (Tom Denton 2004, P.62)

Tom Denton (2004, P. 62-63) added that, some form of engine analyser has become an almost essential tool for fault-finding in modern Vehicle engine systems.

The latest machines are now generally based around a personal computer. This allows more facilities, which can be added to by simply changing the software whilst engine analysers are designed to work specifically with the motor vehicle; it is worth Remembering that the machine consists basically of three parts.

Multimeter.

Gas analyser.

Oscilloscope. (Tom Denton 2004, P. 62-63)

According to Denton (2004) serial communication is an area that is continuing to grow. A special interface is required to read data. This standard is designed to work with a single or Two-wire port, which connects vehicle electronic Systems to a diagnostic plug. Many functions are then possible when a scanner is connected. Possible functions include the following. (Denton, 2004, P. 66)

2.4 Effects of exhaust emissions

Land pollution can affect the general environment of the Earth. Land pollutions leads to loss in the forest cover of Earth and this is in turn going to affect the amount of rain in a season. Less rain mean lesser vegetation. The effect of all different kinds of pollution will eventually lead to problems like acid rains; greenhouse effect, global warming and all these problems have already initiated and need to be curbed before the situation runs out of control. Prabhakar PillaiL, 2012).

William. H and Donald L. Anglin (1996) explain that, all OBD 1 systems are not exactly alike. Therefore, various manufacturers provide different ways to retrieve stored trouble codes. One way is to use malfunction indicator light in the instrument

panel. The light can display stored codes in a series of flashes representing numbers. The second and preferred way is to connect a compatible scan tool or diagnostic computer to the vehicle diagnostic computer to the vehicle diagnostic connector or data-link connector (DLC).It is also called the diagnostic connector the assemble- line diagnostic link (ALDL) connector. The third way is to use the onboard self –diagnostic instrument panel built into some vehicles. The illustration above shows how CHECK ENGINE light flashes on General Motors vehicle is used to retrieve diagnostic trouble codes. The flashes indicate stored diagnostic trouble codes. **For example, a code 12** consists of one flash followed by a pause and then two more flashes. (William. H and Donald L. Anglin., 1996. p. 326),

Allan W. M. Bonnick (2001) also asserted that, as a result of the different technology used in automotive computer controlled systems; it is possible to find a number of different methods of accessing DTCs. Three methods are in general use.

1. Displaying the code as flashes on a dashboard indicator lamp.

2. Connecting an LED or test lamp externally and observing the number of flashes and pauses.

3. Connecting a code reading machine, and/or a scan tool, to the diagnostic port on the ECM. (Allan W. and. Bonnick 2001, P. 66)

Gislason (2011) Car exhaust is toxic at ground level. Exhaust from all combustion engines combine to produce local adverse effects on the health of car users and all innocent bystanders including Technicians and Mechanics. The adverse health effects of car exhaust are pervasive and difficult to measure. (Gislason 2011, P. 3).

Michael Evans (2011) revealed that, it is estimated that every year various forms of transport consume between 20% and 25% of the world's energy and this significantly contributes to the increasingly high levels of greenhouse gases that continue to be released into the atmosphere. Michael Evans (2011)

2.5 **Emission control measures in vehicles**

Toyota motor sales, USA In., (2012), point out that, in 1970 the US Congress had adopted regulations requiring by 1975 a reduction of 90% on the then current emissions requirements. The Federal Environmental Protection Agency was formed and introduced a better method of sampling. Previously all the exhaust gas had been collected in one huge bag and then analyzed. This had the disadvantage that it gave absolutely no indication of how the engine behaved under the different conditions of operation during the test; moreover, in some circumstances, some of the gases interacted in the bag, giving misleading results. (Retrieved from Toyota motor sales, USA In., 2012)

Sherry J. (1998), explain in this Article that, motor vehicle emission are the leading cause of air pollution in Malaysia and as result of that the Malaysia Department of Environment (MDOE) is looking for new way to combat the problem. In 1996 MDOE introduced two regulations to control vehicle emissions, setting exhaust standard for diesel and petrol vehicles. The regulations will require MDOE conduct verification test on vehicles emissions. United States –Asia Environmental partnership (U S – A E P), (1998)

On-Board Diagnostics II systems have been designed to reduce vehicle emissions by monitoring for failure or deterioration of the powertrain control systems on continuous basis. OBD II general requirements are that virtually all emission-control systems must be monitored, Malfunctions must be detected before emissions exceed standards by a specified threshold and in most cases malfunctions must be detected within two driving cycles. The EPA defines On-Board Diagnostics (OBD) II as a system of vehicle component and condition monitors controlled by a central, on-board computer running software designed to signal the motorist when conditions exist which could lead to a vehicle exceeding its emission standards by 1.5 times the standard. (Sosnowski 2002) and Cope 2004, P. 4).

According to Willard W. (2006) exhaust gas recirculation (EGR) allows a proportion of the exhaust gas leaving the engine to be returned to the inlet manifold for distribution to the cylinders again for combustion. This will ensure that most of the unburned fuel in the exhaust gas is burnt. This technique is used primarily to reduce peak combustion temperatures and hence the production of nitrogen oxides (NOx). EGR can be either internal due to valve overlap, or external through a simple arrangement of pipes and a valves connecting the exhaust manifold back to the inlet manifold.

(Willard W. Pulkrabek, 2006, P. 120).

Willard W. Pulkrabek (2009) the exhaust of automobiles is one of the major contributors to the world's air pollution problem. Recent research and development has made major reductions in engine emissions, but a growing population and a greater

number of automobiles mean that the problem will exist for many years to come. During the first half of the 1900s, automobile emissions were not recognized as a problem, mainly due to the lower number of vehicles. As the number of automobiles grew along with more power plants, home furnaces, and population in general, air pollution became an ever-increasing problem. During the 1940s, the problem was first seen in the Los Angeles area due to the high density of people and automobiles, as well as unique weather conditions. By the 1970s, air pollution was recognized as a major problem in most cities of the United States as well as in many large urban areas around the world. Laws were passed in the United States and in other industrialized countries which limit the amount of various exhaust emissions that are allowed by Automobile Vehicles. This put a major restriction on automobile engine development during the 1980s and 1990s. (Willard W. Pulkrabek, 2009 P.30).

James A. Sugar and Corbis (1989) added concerns surround the difference between new vehicle emissions and emissions of cars or trucks in use. Vehicles with good emission control technology that is not properly maintained can become "gross polluters" that is, if proper maintenance schedule is not adhered to and this could be responsible for a significant amount of existing emission problems. New technologies have also been developed to identify emission-equipment control failures, and can be used to help reduce the " pollution" problem. (James A. Sugar and Corbis, 1989, p.6), Described the catalytic converter as after-burner. It oxidizes (burns) any residual fuel vapors unburned hydrocarbons (HC) in the exhaust. It also burns any carbon monoxide (CO) in the exhaust. The exhaust must meet federal emission standards, and if a problem exists that causes emissions to exceed the federal limits by 150%, the OBD II

system is supposed to detect the fault, set a trouble code and turn on the Check Engine light. The OBD II system can't actually measure the concentration of HC or CO in the exhaust, so it compares the upstream and downstream O2 sensor readings to estimate how well the catalyst is actually doing its job of removing pollutants from the exhaust. When the engine is first started, the catalyst is cold and doesn't oxidize (burns) any residual fuel vapors unburned hydrocarbons (HC) in the exhaust. During this time, the switching activity of the upstream and downstream O2 sensors are essentially the same because nothing is happening inside the converter until it reaches the normal operating temperature.

Eran Sher (1998) indicated that, under Ohio regulations; it is the responsibility of the mechanic to obtain all environmental permits that are needed for your business. Air pollution permits are required for air pollution related sources. An air pollution source is any activity that emits substance that contains air pollutants, such as particulates, dust, fumes, gases, mist, smoke, vapors or odors. Eran Sher (1998, P. 2). The efforts to achieve sustainable development, governments worldwide are facing a growing problem of the effects on health induced by air pollutant concentration which are caused by motor vehicle emissions. (WHO/EOS/97.08).

Article retrieved from http://www.epa.gov/obd/pubs/420f09048 opined that, Federal Vehicle Emission Control Warranties for 1995 and Newer Cars and Trucks Contrary to popular belief, California vehicle emission system control warranties, do not replace federal vehicle emission system control warranties. The federal vehicle emission system control warranties remain in full effect in addition to those imposed

by the state of California. There are two types of federal vehicle emission warranties: (1) The Performance Warranty; and, (2) The Design and Defects Warranty.

Denton (2006) explains that, the Motor Vehicle Pollution Control Board was established with a mandate to certify devices proposed to be fitted on cars for sale in California. In addition, The Federal Motor Vehicle Act of 1960 was enacted, requiring Federal research to combat motor vehicle engine pollution. (Denton, 2006 P. 62-63).

Gislason (2011) car exhaust is toxic at ground level. Exhaust from all combustion engines combine to produce local adverse effects on the health of car users and all innocent by standers including Technicians and Mechanics. The adverse health effects of car exhaust are pervasive and difficult to measure. (Gislason, 2011, P. 3). This also collaborated with Prabhakar Pillai (2012) that, land pollution can affect the general environment of the Earth. Land pollutions leads to loss in the forest cover of Earth. This is in turn going to affect the amount of rain. Fewer rains mean lesser vegetation. The effect of all different kinds of pollution will eventually lead to problems like acid rains, greenhouse effect, global warming. All of these problems have already initiated and need to be curbed before the situation runs out of control. Prabhakar Pillai (2012). Towards this direction, a study made by Robin Odach (1987) New York City (NYC) has a significant air pollution problem that causes premature death for many people. It is caused by sunlight interacting with vapors released from motor vehicles, factories and fuel-burning sources. The American Lung Association says the NYC was ranked 16th for ozone pollution when compared to 25 other American cities. Fine particulate matter is another culprit, and it is caused by ash, soot,

diesel fumes and chemical emissions. Particulates burrow their way deep into the lungs and cause asthma, chest pain, wheezing and cancer. Robin Odach (1987).

According to Chris Korleski (2007) Technicians who carry out diagnosis on motor vehicles must be trained and certified by a U.S. EPA approved organization. Training must include instruction on the proper use of equipment, regulatory requirements, importance of refrigerant recovery and the effects of ozone depletion. To be certified, technicians must pass a test demonstrating their knowledge in these areas. (Chris Korleski, 2007. P. 5).

The efforts to achieve sustainable development, governments worldwide are facing a growing problem of the effects on health induced by air pollutant concentration which are caused by motor vehicle emissions. (WHO/EOS/97.08)

According to Willard W. Pulkrabek (2009) the exhaust of automobiles is one of the major contributors to the world's air pollution problem. Recent research and development has made major reductions in engine emissions, but a growing population and a greater number of automobiles mean that the problem will exist for many years to come. During the first half of the 1900s, automobile emissions were not recognized as a problem, mainly due to the lower number of vehicles. As the number of automobiles grew along with more power plants, home furnaces, and population in general became an ever-increasing problem. During the 1940s, the problem was first seen in the Los Angeles area due to the high density of people and automobiles, as well as unique weather conditions. By the 1970s, air pollution was recognized as a major problem in most cities of the United States as well as in many large urban areas

around the world. Laws were passed in the United States and in other industrialized countries which limit the amount of various exhaust emissions that are allowed by Automobile Vehicles. This put a major restriction on automobile engine development during the 1980s and 1990s. (Willard W. Pulkrabek 2009 P.30).

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This research were mainly to point out the Environmental pollution caused by In-Efficient diagnosis by vehicles repair Garages in the Tamale Metropolis and highlight the Environmental impact of their activities, as well as the Health risk associated with vehicle repair and maintenance services by Automobile repair Garages and the various interventions by individual Nations Globally aimed at addressing this canker and to identify them and offer suggestions for its mitigation.

To this effect, there was the need to collect data regarding the perception of respondents through pragmatic means to have significant evidence in any claim.

Therefore, this chapter describes the following.

i. The Research design
ii. Population and location
iii. Sample and sampling procedure
iv. The research instruments
v. Validity and reliability of research instruments
vi. Data collection.

3.1 Research design

Due to the nature and purpose of this study, the assessment research design was used. Because the research was a fact- finding one and seeks to describe the Environmental impact of the Automobile repair Garages as a result of In-Efficient diagnostics

procedures used by the Garages and also assess the health effects, as well as their skills levels in handling after sales service of these vehicles.

3.2 Population and location

The population for this study was the Managers of Automobile repairs workshops, workshop Technicians, Mechanics Apprentices both in the formal and the informal sector. This is because the study was about the Environmental and health impact due to In-Efficient diagnosis by these Automobile repair industry and therefore sample of the people or groups of people who were connected with the diagnosis and repairs of Automobile vehicles needed to be contacted for their views on the subject.

The entire population was located in both, the industrial area or Magazine, a well known location of majority of Artisans, private Automobile workshops in the Tamale Metropolis and other locations in the Metropolis of Northern Region of Ghana.

3.3 Sample and sampling procedure

Due to financial and mobility constraints it was impossible for the researcher to be able to collect data from the entire population identified above. It therefore became necessary to sample the population, and this was exactly what the researcher did as follows.

A total number of sixty (60) respondents were selected and the respondents were comprised of specifically managers of Automobile repair Garages, Technicians, and mechanics workshops, both in the formal and the informal sector. The Automobile repair workshops managers were selected from the industrial area and around some parts of the Tamale Metropolis. The mechanics were selected from those shops from

where the managers are trainers as well .All the selections were made at random process.

3.4 Research instrument

Questionnaires were used; however, interviews were also used extensively in most cases because majority of the Automobile repair workshops at the informal sector were illiterate respondents. The questionnaire comprised a preamble and two (2) sections.

These sections are A and B.

Section A, looked at the background of respondents in terms of age and educational status. Section B looked at the respondent's general knowledge of Environmental pollution, the health risk associated with Automobile repairs and diagnosis and the basic diagnostic knowledge of respondent on how to Diagnoses of Vehicles with Electronics managed cars coming into the Tamale Metropolis, of Northern Region of Ghana.

Where interviews were conducted, the same questionnaire was translated into the local languages (Dagbani, Gonja etc) and their responses were be noted.

3.5 Validity and reliability of instruments; the research instruments, especially the questionnaire was constructed and given to some of the Automobile repair Garages, Technicians, mechanics, managers of Automobile workshops and Teachers of Automobile Engineering programmes in some of the Vocational Institutions in the Tamale metropolis and some of the Engineering teachers at Tamale

Polytechnic. The final copy was sent to my supervisor to scrutinize it very critically, making very valuable comments and corrections.

The final construction was administered to few people for validity. Thereafter the entire Sixty (60) was distributed to the selected subjects. As already mentioned, the questionnaires was read and explained in some of the local Languages for illiterate respondents to understand so as to give their responses. Care was taken to ensure that no responses were imposed on respondents. They were allowed give their responses totally independently. The questionnaires were meticulously followed and retrieved.

3.6 Data analysis; charts and tables were used to analyse the data. Each question was examined with regards to the number of responses and qualified into percentages. The response with the highest percentage were considered as the general opinion of the population for that particular item and conclusions for statements was drawn, based on these general emerging opinions.

CHAPTER FOUR

RESULTS AND DISCUSIONS

4.0 Introduction

The chapter presents the data gathered from the field. The data were represented by charts and tables. Data were also presented in relation to the literature review and compared to the data collected from the field. The results were analysed in the order of the research questions. The researcher selected the sample based on targeted population using the non-probability sampling method of random sampling, specifically the purposive sampling technique. This method ensured that representative samples of all the mechanics, Technicians and Manager of Automobile workshops were covered in the sample.

The total number of questionnaires administered was sixty (60) to the mechanics, Technicians and Managers of Automobile workshops to assess the effects of Environmental pollution in that sector.

4.1 Demographics

Table 4.1: Age of Respondents

Response Items	Frequency (N)	Percent (%)
15 - 20	7	11.7
21 - 30	30	50.0
31 - 40	16	26.7
41 - 50	7	11.7
Total	**60**	**100.0**

Source: Field Data 2014

Demographic responses from the respondents showing in table 4.1 above portrays that among the total 60 respondents half 50% are between the ages of 21 – 30 years whereas 26.7% are aged between 31 – 40 years. Also, 7 of the respondents representing 11.7% are between the ages of 15 – 20 years as well as respondents between the ages of 41 – 50 years.

4.2 Educational level

Response Items	Frequency (N)	Percent (%)
Technical/Vocational	28	46.7
O level/SHS	5	8.3
JHS	7	11.7
Primary	1	1.7
Others	19	31.7
Total	**60**	**100.0**

Source: Field Data 2014

Table 4.2 Educational level

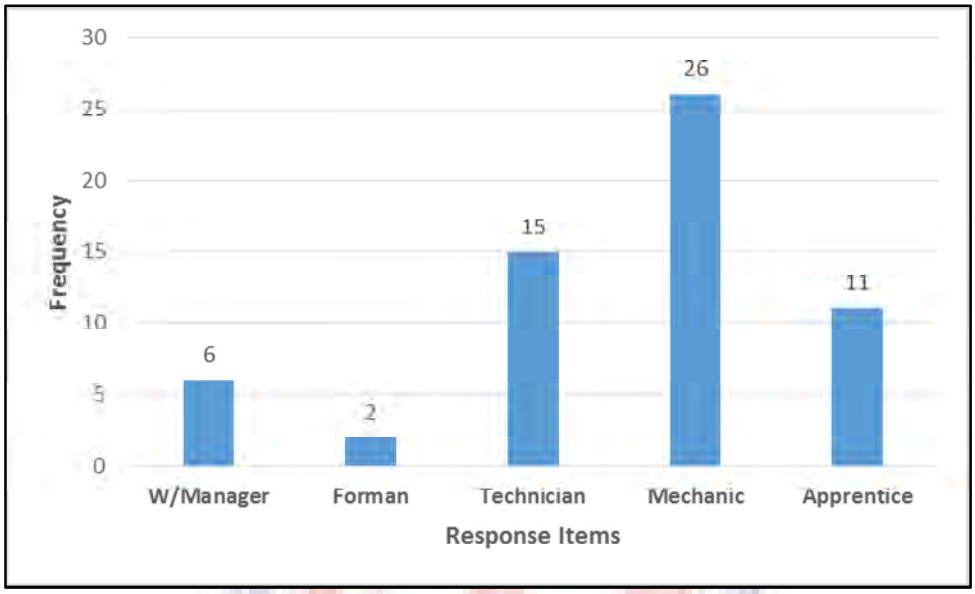
Table 4.2 showing respondent's level of education shows that majority of the respondents (n=28, 46.7%) have had Technical/Vocational education. Again, 5 respondents comprising of 8.3% of the total respondents have had 'O' Level or SHS education. Meanwhile, 7 respondents also making up 11.7% of the respondents got educated up to JHS whiles 1 representing 1.7% had Primary education. Also, 19 respondents being 31.7% had 'Other' forms of education.

The importance of education cannot be over-emphasized as it is needed in every sphere of human endeavour. Mechanics in the automotive repair sector therefore should, at least, have some knowledge of the systems, tools, equipment of the sector

and the materials and processes they use. They should be able to read the manual instructions of the vehicles and diagnostic equipment that they use and this knowledge is gained through formal education.

The analysis of the mechanics, Technicians and apprentices of automotive repair sector indicated that, majority of the respondents (n=28, 46.7%) have had Technical/Vocational education and again 5 of the respondents comprising of 8.3% have had 'O' Level or SHS education. Meanwhile, 7 respondents also making up 11.7% of the respondents got educated up to JHS whiles 1 representing 1.7% had Primary education. Also, 19 respondents being 31.7% had 'Other' forms of education.

However, most of the mechanics in this sector have had basic education, but there is still the need for further education or development to improve their knowledge, as emission free diagnosis is important to ensure that plants, animals and human lives are protected. For example, the mechanics and apprentices should have basic knowledge about the diagnostic procedures for various management systems. Knowledge of the emission associated with the repair job is very essential to the environment. This is confirmed by an article published in AutoTap (2011), only qualified, trained technicians equipped with the appropriate diagnostic and repair equipment should conduct OBD related service. With the population of modern technology cars growing, all dealerships and independent repair shops should have qualified personnel for this service. Vehicle owners should ask at their service facility if the technicians have received proper training, and have access to the necessary equipment to properly service OBD equipped vehicles.



Source: Field Data 2014

Figure 4.3 Rank of Respondents

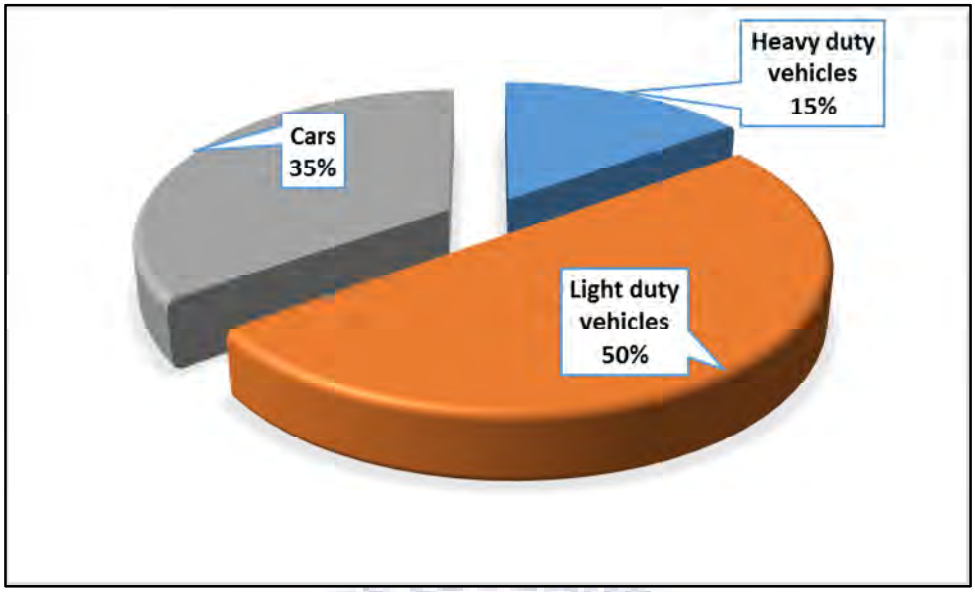
Figure 4.3 portrays the rank of respondents used in the study. The results shows that majority of the respondents were 'Mechanics' whiles 15 respondents were 'Technicians'. In addition, 11 respondents were 'Apprentices' whereas 6 respondents were 'W/Manager' and 2 respondents being 'Forman'. The above analysis shows that majority of the respondents were 'Mechanics' who are involve in the repair work in various workshops across the Tamale Metropolis.

Table 4.4 Years spend in the repair industry

Response Items	Frequency (N)	Percent (%)
Less than a years	5	8.3
1-2 years	12	20.0
3-4 years	11	18.3
5-6years	9	15.0
More than 6 years	23	38.3
Total	**60**	**100.0**

Source: Researcher's survey, 2014

Further, the results showing in table 4.4 above suggests that majority of the respondents 23 representing 38.3% of the respondents have more than 6 years of occupational experience in the repair industry. Also, 9 respondents making up 15% of the total respondents have between 5 – 6 years of repair experience whereas 11 respondents being 18.3J% have 3 – 4 years. 12 respondents have between 1 – 2 years of experience and 5 respondents being 8.3% have less than a year experience in the repair industry.



Source: Researcher's survey, 2014

Figure 4.5 Type of vehicles repaired

Respondents were asked to indicate the type of cars they repair and the results as showing in figure 4.5 above depicts that exactly half of the respondents 50% reported of repairing Light Duty Vehicles whereas 35% repaired cars and 15% repaired Heavy Duty Vehicles.

The types of vehicles repair by mechanics become an essential part of automotive diagnosis as a result of interventions being made to reduce vehicular emission for the last three decades and this was confirmed by Eran Sher(1998). The emission control technology, developed with much hard work by engineers over the past 25 years, which is very effective at reducing emissions from most cars on the road for much of their useful life, but its failure to achieve this control as small fraction of the vehicles live will offset the gains made. The future efforts to reduce emissions must somehow deal with this reality. Eran Sher(1998, P. 15-17), on the other hand

T.K. Garrett (2001) indicated that, attention was first directed to atmospheric pollution by Automobile vehicles in Los Angeles in 1947. Subsequently, in 1952, Arie J. Haagen-Smit asserted on the basis of his research that, at least locally, it was due mainly to automotive exhaust emissions. Stephen J. Gislason (2011, P. 3)

Table 4.6 Number of skilled mechanics in your workshop

Response Items	Frequency (N)	Percent (%)
1	2	3.3
2	12	20.0
3	19	31.7
More than 3	27	45.0
Total	**60**	**100.0**

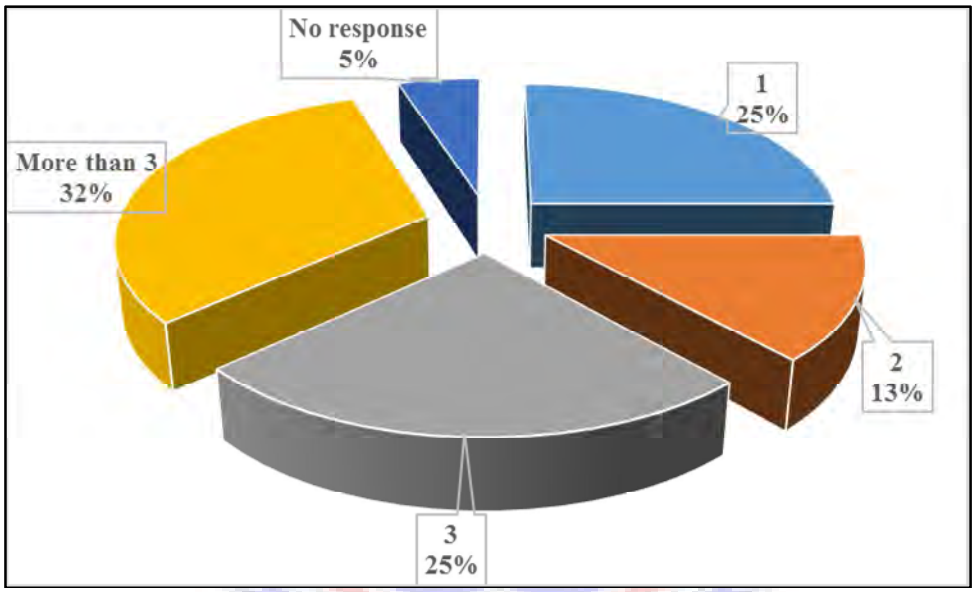
Source: Researcher's survey, 2014

Table 4.6 above shows the number of skilled mechanics in respondent's workshops. Analysis of the results shows that there were more than 3 skilled mechanics in respondent's shops as (n=27, 45%) of the total respondents report. The results also show that 19 respondents comprising 31.7% have 3 mechanics in their workshops whereas 12 respondents representing 20% have 2 mechanics and 2 respondents being 3.3% have only 1 mechanic.

Rodrigue (2013) explained that, in order to meet the large number of vehicles entering the country and also meet Environmental Protection Laws across the world, it is important for that mechanics to acquired update skills to meet set rules and regulations on emission diagnosis. The role of skills mechanics in this regard is essential since poor inspection and diagnosis leads to poisonous gases been release to the atmosphere as it was confirmed by Emissions or smog is a generic term used to

describe certain harmful gases in the exhaust. Hydrocarbons (HC), Carbon Monoxide (CO) and Oxides of Nitrogen (NOX) are usually measured in an emissions test. The state and federal government place certain limits on each of these harmful gases emitted.

Figure 4.7 Number of unskilled mechanics in the workshop?



Source: Researcher's survey, 2014

Figure 4.7 above portrays the distribution of unskilled mechanics among the respondents. The diagram shows that 32% of the respondents reported they have more than 3 respondents. Also 25% of the respondents reported of having 3 mechanics in their workshop. 13% of the respondents reported of having 2 respondents and 25% again reported of having only 1 respondent. However, 5% failed to respond to this question.

Skills and experience is vital for efficient inspection and diagnosis in order reduces poisonous exhaust gases being release to the atmosphere which has become a

serious challenge to the automotive repair sector. A lot of effort is being made, especially in the developed countries aim at reducing vehicular pollution and various interventions has being made in this regard and this was confirmed by an article retrieved from http://www.epa.gov/obd/pubs/420f09048. Federal Vehicle Emission Control Warranties for 1995 and Newer Cars and Trucks Contrary to popular belief, California vehicle emission system control warranties, do not replace federal vehicle emission system control warranties. The federal vehicle emission system control warranties remain in full effect in addition to those imposed by the state of California. There are two types of federal vehicle emission warranties: (1) The Performance Warranty; and, (2) The Design and Defects Warranty.

CAN IMPROVED KNOWLEDGE OF THE SYSTEMS BY MECHANICS AID IN SPEEDY AND EFFICIENT DIAGNOSTICS

Table 4.8 Does Education play a central part in diagnosing emission controlled vehicles?

Response Items	Frequency (N)	Percent (%)
Yes	54	90.0
No	6	10.0
Total	60	100.0

Source: Researcher's survey, 2014

Showing in Table 4.8 above shows that 54 respondents representing 90% responded 'Yes' to the fact that education play a central part in diagnosing emission controlled vehicle. On the contrary 6 respondents representing 10% disagreed by responding 'No' to the question.

In response to whether education will aid in speedy diagnosis of cars. The analysis above shows that majority of the respondents agreed that education will improve their knowledge on the various systems in the Automotive repair sector and also read repair manuals. The mechanics will also be able read and interpret diagnostic trouble codes in accordance with emission regulations. It will enhance their skills and knowledge in safety procedures, spare parts handling in their various workshops and this will also help the Apprentices under training to lean in their knowledge acquisition.

Over the years a lot of effort is being made in order to minimize vehicle pollution and this cannot be achieve without efficient vehicle inspection and diagnosis by mechanics in the automobile repair industry. The above analysis showed that almost all the respondents (93%) agreed that education plays an important role in diagnosing modern automobile vehicles as result of introduction of electronics to manage the various systems in order to reduce environmental pollution and this is evident in the various legislations across the world and which was confirmed by Toyota motor sales, (2012), point out that, in 1970 the US Congress had adopted regulations requiring by 1975 a reduction of 90% on the then current emissions requirements. The Federal Environmental Protection Agency was formed and introduced a better method of sampling. Previously all the exhaust gas had been collected in one huge bag and then analyzed. This had the disadvantage that it gave absolutely no indication of how the engine behaved under the different conditions of operation during the test; moreover, in some circumstances, some of the gases interacted in the bag, giving misleading results.

Table 4.9 Understanding of the systems is required in diagnosing modern vehicles

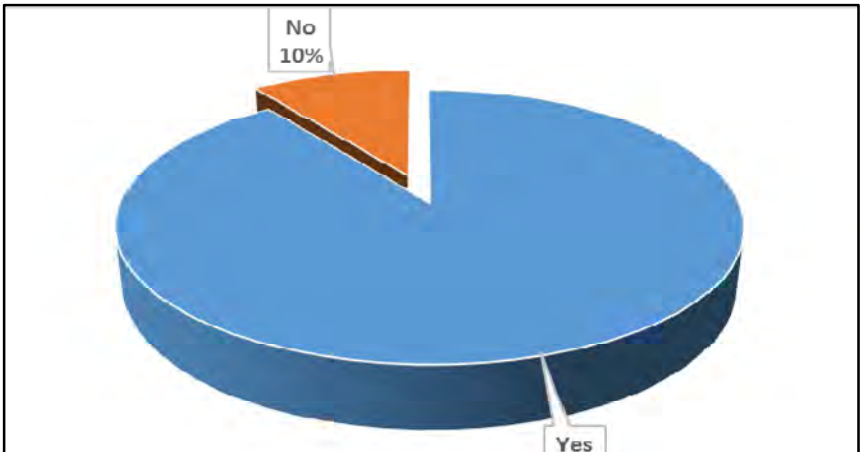
Response Items	Frequency (N)	Percent (%)
Yes	53	88.0
No	7	12.0
Total	**60**	**100.0**

Source: Researcher's survey, 2014

Presenting above in Table 4.9 indicates that 53 comprising 88% of the respondents responded 'Yes' to the question. However, 7 respondents also being 12% of the respondent's population responded 'No' to that effect.

Maintenance and inspection has become sophisticated with the advent of microprocessors into the Automotive industry to manage the various systems to improve fuel consumption and also meet stringent environmental protection laws across the globe and this has made diagnosis of automobile vehicles gone beyond the rule of the thumb. Mechanics needs some level of understanding of the systems and procedures involve in order ensure that proper diagnostic standard are meet. This is in agreement with Rimkus (2007) Automotive diagnostics is one of the main subjects in training car service specialists. The diagnostics subjects consist of theoretical and practical training. Various types of engine management systems work and their faults are investigated. The main equipment consists of engine simulators. The development of using micro processing technologies in automotive controls requires more sophisticated diagnostics equipment. Most developing diagnostics equipment are systematic testers which takes the information from the electronic control unit ECU about trouble codes and display the parameters. (Rimkus, 2007)

Figure 4.10 Do you know that the Check Engine Light can be used to retrieve on-Board Diagnosis Trouble Codes



Source: Researcher's survey, 2014

Showing in Figure 4.10 above portrays that 90% of the respondents responded 'Yes' whereas 10% responded 'No' to the fact that check engine light can be used to retrieve on-Board Diagnosis.

Retrieving diagnostic trouble codes is the first step in diagnosing cars equipped with On Board Diagnosis systems (OBD), mechanics requires in-depth knowledge of the processes and procedures in retrieving and interpreting the Diagnostic Trouble codes. Even though 90% of the respondents responded 'Yes' to the awareness of the check Engine light in retrieving on-Board Diagnostics trouble codes, they lack the knowledge on how to proceed with it. This is in contrast to what Snap-on (2011), that, malfunction indicator light in the instrument panel is used retrieved trouble codes through a series of flashes representing numbers and the second and preferred way is to connect a compatible scan tool or diagnostic computer to the vehicle diagnostic computer to the vehicle diagnostic connector or data-link connector (DLC). The illustration above shows how CHECK ENGINE light flashes on General Motors

vehicle is use to retrieve diagnostic trouble codes. The flashes indicate stored diagnostic trouble codes. **For example, a code 12** consists of one flash followed by a pause and then two more flashes. Snap-on (2011), On the other hand, Allan Bonnick (2001) found that, as a result of the different technology used in automotive computer controlled systems; it is possible to find a number of different methods of accessing DTCs. Three methods are in general use.

1. Displaying the code as flashes on a dashboard indicator lamp.

2. Connecting an LED or test lamp externally and observing the number of flashes and pauses.

3. Connecting a code reading machine, and/or a scan tool, to the diagnostic port on the ECM. (Allan Bonnick 2001, P. 66)

Table 4.11 Circuit can damage electronic components

Response Items	Frequency (N)	Percent (%)
Yes	54	90.0
No	6	10.0
Total	**60**	**100.0**

Source: Researcher's survey, 2014

From Table 4.11, more than two-thirds of the respondents (n=54, 90%) responded 'Yes' to being aware that short circuiting can damage electronic components. However, 6 respondents representing 10% reported 'No' of being aware.

Bare wires should be insulated immediately if it is exposed to prevent it from torching any metal part of the car to for stall the electricity from bypassing to earth since this has a potential of inducing high voltage into the system and since the electronic components has very low electrical resistance would damage or blown off

fuses. The right procedures must be followed at all times. The above analysis showed that, more than two-thirds of the respondents (n=54, 90%) responded ‘Yes’ to being aware that short circuiting can damage the electronic components and this must be avoided at all cost. This finding supports what Mike allen (2006) said that the source of the short circuit is obvious be a wiring which is dangling under the dashboard. A short circuit occurs when an energized conductor touches either the frame or body of the car or another wire. Shorts to ground usually will have low enough resistance to draw sufficient current to blow the fuse. (Mike allen 2006). The finding also corroborates with the study by Morris Rosenthal (2011) that to check for a short circuit after a blown link. Don't just replace the blown fusible link without checking if it blew due to a short circuit that is still in effect. A short circuit, by definition, is a circuit with an unexpected path to ground, meaning the electricity will return to ground without powering whatever device the circuit is intended to power. Morris Rosenthal (2011, p.6). Don Nisbett (2012) study revealed that, as a vital part of modern cars, wiring harnesses containing thousands of assembly components connect various electronic systems, enabling them to work together. A single failure in any harness can affect the entire system. Nevertheless, to accommodate the growing demand for in-car electronics, the complexity of automotive wiring harnesses continues to grow, increasing the need to detect broken or shorted wires quickly and easily. Don Nisbett (2012).

Table 4.12 Cutting wires in the emission controlled cars leads to total malfunctioning

Response Items	Frequency (N)	Percent (%)
Yes	56	93.0
No	4	7.0
Total	**60**	**100.0**

Out of the 60 respondents surveyed 56 respondents comprising of 93% reported 'Yes' to knowing that cutting wires in the emission controlled cars can lead to total malfunction. On the contrary only 4 (7%) of the respondents reported otherwise.

Vehicles with electronic control systems are networked to ensure that the various electronic control units (ECUs) communicate with each other and this makes it difficult to function when any of the wires are cut or disconnected. These used to happen in the old model cars before the introduction of electronics to manage the various systems in the Automobile industries, which totally agreed to Derek Newbold and Allan Bonnick. (2005) reported that, when a number of computer controlled systems on a vehicle are required to communicate with each other, as happens with cruise control, traction control, diagnostics and other systems, the computers are connected to each other for communication purposes. Linking computers together, for communications purposes, is called networking and the lines (wires) that are used for this purpose are known as buses. (Allan Bonnick and Derek Newbold, 2005, P. 238)

Table 4.13 Disconnecting the battery terminals on OBD I cars can turn off check Engine light

Response Items	Frequency (N)	Percent (%)
Yes	54	90.0
No	6	10.0
Total	**60**	**100.0**

Source: Researcher's survey, 2014

In Table 4.13 and among the total 60 respondents, 54 (90%) of the respondents stated that they do know that disconnecting the battery terminals on OBD I cars can turn off check engine light. However, 6 (10%) of the respondents indicated that they do not know that when the battery terminals on OBD I cars are disconnected they can turn off check engine light of the car. Though 54 (90%) of the mechanics agreed that, they do know that disconnecting the battery terminals on OBD I cars can turn off check engine light, which goes contrarily to the study that, Setting trouble codes in older vehicles (OBD I), those made before 1996, disconnecting the computer's power source or disconnecting a battery cable erases fault codes and turn off the Check Engine Light, at least temporarily. If the problem persists, the code will reset and the Check Engine Light will come on. Many newer vehicles, you do NOT have to disconnect the battery because doing so can wipe out the computer's memory settings. This may affect the operation of the transmission, climate control system and other function doing so can wipe out the computer's memory settings. This may affect the operation of the transmission, climate control system and other functions. In 1996 and newer vehicles, a scan tool or code reader must be used to erase codes and turn the Check Engine Light off. Snap-on (2011)

Table 4.14 Vehicles coming into Region are now equipped with emission control devices

Response Items	Frequency (N)	Percent (%)
Yes	51	85.0
No	9	15.0
Total	**60**	**100.0**

Source: Researcher's survey, 2014

In Table 4.14, respondents were asked to indicate whether they are aware of the fact that vehicles coming into the region are now equipped with emission control devices. The output as showing in the table above suggests that 51 respondents representing 85% of the total respondents responded 'Yes' to being aware. Nine respondents (15%) on the other hand opined otherwise to that effect.

The awareness of the electronic managed vehicles with emission control devices in the Tamale Metropolis is nonetheless not in doubt, since the output as shown in the table above suggests that 51 respondents representing 85% of the total respondents responded 'Yes' to being aware of the emission control devices in the vehicles coming into Metropolis. Since the introduction of electronics to manage the various systems in the automotive industry to reduce vehicular pollution, as result, there has been an increase of these electronic managed vehicles in the country. This is supported by the previous findings by Denton (2006) who explains that, the Motor Vehicle Pollution Control Board was established with a mandate to certify devices proposed to be fitted on cars for sale in California. In addition, The Federal Motor Vehicle Act of 1960 was enacted, requiring Federal research to combat motor vehicle engine pollution. (Denton, 2006 P. 62-63).

Table 4.15 Check Engine Light is a warning signal

Response Items	Frequency (N)	Percent (%)
Yes	51	95.0
No	9	5.0
Total	**60**	**100.0**

Source: Researcher's survey, 2014

In Table 4.15 above, respondents were asked to indicate whether they know that the check Engine Light is a warning signal. From the output almost all respondents (n=51, 95%) responded 'Yes' to knowing that the Engine Light is a warning signal. Meanwhile, 9 respondents being 5% of the total respondents responded 'No' suggesting that they do not know that it is a warning signal.

A malfunction indicator lamp (MIL), also known as a check engine warning light on the dashboard is often the first an owner of a car used to know if there is a problem with their car in electronically controlled engine management system. It is found on the instrument panel of most automobiles vehicles. When illuminated, it is typically either an amber or red color. On vehicles equipped with OBD-II, the light is either steady when there is minor fault or when a component failed. When the MIL comes on, the engine control unit stores a fault code related to the malfunction, which can be retrieved with a scan tool. The malfunction indicator lamp usually bears CHECK ENGINE, SERVICE ENGINE SOON, or a symbol of an engine. This was in line with Snap-on (2011) explains that, Malfunction Indicator Lamp (MIL) or CHECK ENGINE light as it is more commonly called is essentially an emission warning light. If the light comes on, it means the Onboard Diagnostics II system (OBD II) has

detected an emissions-related problem. OBD II is designed to turn on the MIL light if a problem occurs that may cause emissions to exceed federal limits by 150 percent. The problem has to occur more than once, and it must be significant enough to create a potential emissions problem or serious enough to prevent a vehicle from passing an emissions test. On the other hand, CarleySoftware (2009), indicated that, the Malfunction Indicator Lamp (MIL) or CHECK ENGINE light as it is more commonly called, is essentially an emission warning light. If the light comes on, it means the Onboard Diagnostics II system (OBD II) has detected an emissions-related problem. Carley Software (2009),

Table 4.16 Reference to the dash board panel for the check engine light on diagnosis

Response Items	Frequency (N)	Percent (%)
Yes	52	87.0
No	8	13.0
Total	**60**	**100.0**

Source: Researcher's survey, 2014

From Table 4.16, respondents were asked to indicate whether checking the dash board panel for the check engine light in diagnosis. The result shows that 52 respondents comprising 87% of total respondents responded 'Yes' to always checking the dash board. However, only 8 respondents being 13% responded 'No to the effect of always checking the dash board panel for the Engine Light in diagnosis.

This is a critical area to mechanics when carrying out repairs on cars, to ensure that the check engine light goes off after the problem had been solved. The above analysis showed that 52 respondents comprising 87% of total respondents responded 'Yes' to

always checking the dash board. However, only 8 respondents being 13% responded 'No to the effect of always checking the dash board panel for the Engine Light in diagnosis.

Items located on the dashboard includes gauges such as a speedometer, tachometer, odometer and fuel gauge, and indicators such as gearshift position, seat belt warning light, parking-brake-engagement warning light and an engine-malfunction light. There may also be indicators for low fuel, low oil pressure, low tire pressure and faults in the airbag (SRS) system. Heating and ventilation controls and vents, lighting controls, audio equipment and automotive navigation systems are also mounted on the dashboard.

Allan W. and Bonnick (2001) when the diagnostic check is completed the 'service wire' must be removed from the 'check engine' connector and then the diagnostic code must be cancelled. After the fault has been rectified, the diagnostic code stored in the Electronic Control Unit (ECU) memory must be cancelled. In some Toyota models, this is achieved by removing the appropriate fuse for a period of 10 seconds or more, depending on the ambient temperature, with the ignition switched off. (Allan W.and Bonnick , 2001, P. 69)

Table 4.17 Training on how to use the Diagnostic Equipment

Response Items	Frequency (N)	Percent (%)
Yes	28	47
No	32	53
Total	**60**	**100.0**

Source: Researcher's survey, 2014

Table 4.17 presented above shows that more than half of the respondents (n32, 53%) do not have any training on how to use the Diagnostic Equipment. However, 28 (47%) respondents responded 'Yes' to receiving training on how to use the Diagnostic Equipment. The capabilities of Mechanics and Technicians in performing diagnosis and repair work are linked to their experience and this is achieved through training. The above analysis shows that more than half of the respondents (n32, 53%) do not have any training on how to use the Diagnostic Equipment. However, 28 (47%) respondents responded 'Yes' to receiving training on how to use the Diagnostic Equipment. This is contrarily to report by According to Chris Korleski (2007) Technicians who carry out diagnosis on motor vehicles must be trained and certified by a U.S. EPA approved organization. Training must include instruction on the proper use of equipment, regulatory requirements, importance of refrigerant recovery and the effects of ozone depletion. To be certified, technicians must pass a test demonstrating their knowledge in these areas. (Chris Korleski, 2007, p. 5).

Table 4.18 knowledge on the emission controlled components

Response Items	Frequency (N)	Percent (%)
Yes	15	25
No	45	75
Total	**60**	**100.0**

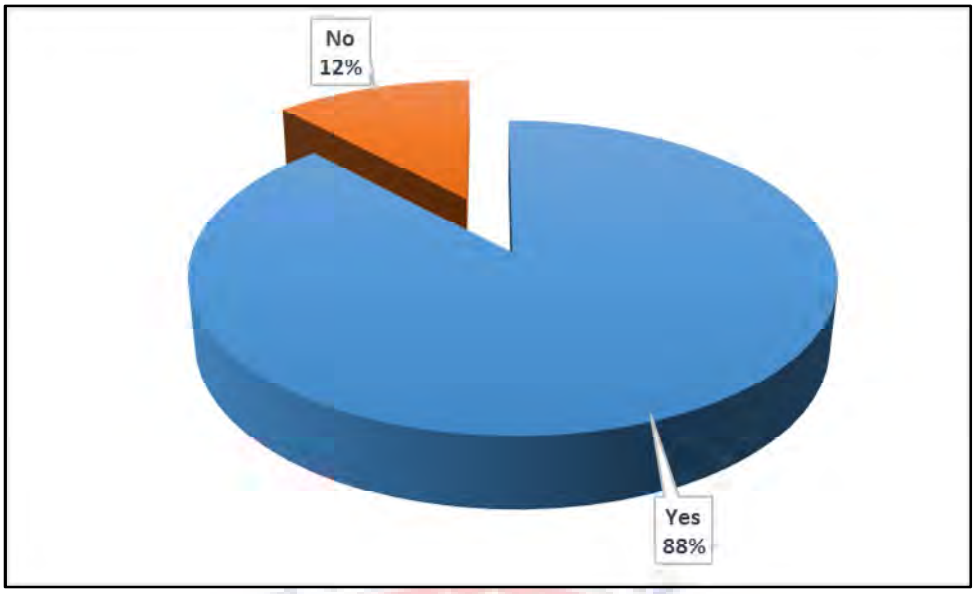
Source: Researcher's survey, 2014

In Table 4.18, two-thirds of the respondents (n=45, 75%) responded 'Yes' to having knowledge on the emission controlled components, whereas 15 respondents 25% responded 'No' to have that kind of knowledge on emission controlled components.

There are numerous components that if they are not working properly, can cause high emissions levels. The mechanic should read each of the components description and operation in the emission control system section of the manufacturer's manual covering the vehicle in order to gain a working knowledge of each system or components to ensure that each component is working properly to meet the emissions standards.

An Article retrieved from http://www.ertl.jpl~hirol Described the catalytic converter as after-burner. It oxidizes (burns) any residual fuel vapors unburned hydrocarbons (HC) in the exhaust. It also burns any carbon monoxide (CO) in the exhaust. The exhaust must meet federal emission standards, and if a problem exists that causes emissions to exceed the federal limits by 150%, the OBD II system is supposed to detect the fault, set a trouble code and turn on the Check Engine light. The OBD II system can't actually measure the concentration of HC or CO in the exhaust, so it compares the upstream and downstream O2 sensor readings to determine how efficient the catalyst is actually functioning in dealing with the pollutants from the exhaust. Denton (2004) found that, the Catalytic converters stringent regulations in most parts of the world have made the use of a catalytic converter almost indispensable. The three-way catalyst (TWC) is widely use by most manufacturers. It is a very simple device and looks similar to a standard exhaust box. Note that, in order to operate correctly, however, the engine must be run at correct air fuel ratio (stoichiometry) or very near to stoichiometry. (Denton, 2006 p. 49)

Figure 4.19 Loose harness connectors turns on check Engine Light



Source: Researcher's survey, 2014

The Figure 4.19 showing above presents respondent's responses on whether they know that loose harness connectors can cause check engine light to come on. The result shows that more than two-thirds of the respondents are aware of this as 88% responded 'Yes'. Meanwhile 12% of the respondents responded 'No' that is they are not aware.

Routine maintenance should include visual checks of electrical circuits and connections and also similar checks of fuel lines. Mileage based servicing will include renewal of air filters, servicing the carbon canister, inspecting and cleaning or renewing and fuel filters. Since the introduction of European On Board Diagnostics (EOBD), all emissions related functions, such as the fuel system, are constantly monitored by the engine computer (ECM). In the event of a defect in any part of the fuel system, the malfunction indicator lamp (MIL) will alert the driver and fault codes will be stored in the computer. (Derek Newbold and Allan Bonnick. 2005 P. 106)

Table 4.20 Knowledge of Diagnostic Trouble Codes

Response Items	Frequency (N)	Percent (%)
Yes	50	83
No	10	17
Total	**60**	**100.0**

Source: Researcher's survey, 2014

In Table 4.20 above, the respondents were asked to indicate whether they know that there are trouble codes. The output shows that more than two-thirds of the respondents (n=50, 83%) reported of knowing that there are trouble codes while 10 (17%) responded 'No' that is not being aware of that fact.

Mechanics knowledge about the trouble codes cannot be over emphasized as modern engine management use European or US on-board diagnostic standards. European on-board diagnostic systems (EOBD) require that emissions related trouble codes (DTCs) are available through a standard connection that permits an approved repairer to gain access to the DTCs by means of an appropriate scan tool. This finding supports what Derek Newbold and Allan Bonnick (2005) explained that, when a microcontroller (computer) is controlling the operation of an automotive system, such as engine management, it is constantly taking readings from a range of sensors. These sensor readings are compared with readings held in the operating program and if the sensor reading is within the program value in the Read Only Memory ((ROM), the microcontroller will make decisions about the required output to actuators, such as injectors. If the sensor reading is not within limits it will be read again and if it

continues to be 'out of limits', a fault code will be stored in a section of Random Access Memory (RAM). (Derek Newbold and Allan Bonnick, 2005 P. 238).

Table 4.21 Interpretation of Trouble Codes by Mechanics

Response Items	Frequency (N)	Percent (%)
Yes	22	37
No	38	63
Total	**60**	**100.0**

Source: Researcher's survey, 2014

For respondents who can interpret the trouble codes, the results showing in Table 4.21 suggests that more than half of the respondents cannot do that activity as 38 (63%) of the respondents responded 'No' whereas 22 comprising 37% responded 'Yes' to being able to interpret the trouble codes.

It is Possible to extract information from ECUs using a Simple Diagnostic scanners or a standard diagnostic computer with appropriate software to be able to read and interpret trouble codes. The above analysis suggests that more than half of the respondents cannot read and interpret the codes as 38 (63%) of the respondents responded 'No'. This is contrarily to the study made by

Anglin (1997) point out that, special diagnostic procedures, Scan tools and other special testers may be required to locate the trouble. To use diagnostic trouble codes (D T C), you must first know how to retrieve the trouble codes. You must also be able to understand and interpret what the trouble codes mean. Furthermore, you must know which circuits are monitored by the computer and which are not is important to interpreting trouble codes. (Anglin, 1997).

Denton (2004) in this direction explains that, the first character of the diagnostic code relates to the system of the vehicle that generated the code:

P _ Powertrain

B _ Body

C _ Chassis

U_ Network

The next character can be either 0 or 1:

0 _ Standard (SAE) OBD code

1 _ Manufacturer's own code

The next character identifies the specific part of the system concerned. For the Powertrain systems

These are:

1 _ Fuel and air metering

2 _ Fuel and air metering, specifically injector

Circuit

3 _ Ignition system and misfire detection

4 _ Auxiliary emission controls

5 _ Vehicle speed control and idle control system

6 _ Computer output circuit

7 _ Transmission related faults

8 _ Transmission related faults

The last two numbers identify the specific fault as seen by the on-board systems. (Denton, 2004, P. 79).

Table 4.22 Diagnostic trouble codes and meanings

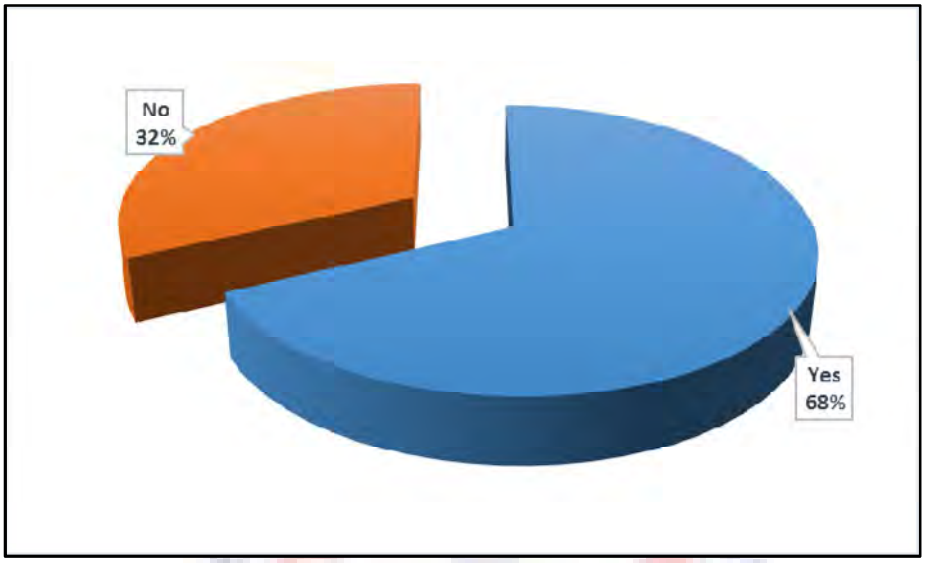
Response Items	Frequency (N)	Percent (%)
Yes	48	80
No	12	20
Total	**60**	**100.0**

Source: Researcher's survey, 2014

From Table 4.22, more than two-thirds of the respondents (n=48, 80%) are aware that the diagnostic trouble codes have their meanings. However, only 12 respondents representing 20% of the total respondent population thought otherwise by responding 'No' that is not being aware that the diagnostic trouble codes have meaning.

Steve & Lynley McAfee (2002) a misfire will cause the check engine light to flash while the misfire is occurring. A misfire that occurs in a given cylinder will also set a p030x trouble code where "x" will be the number of the cylinder that is misfiring. For example, a p0302 trouble code would tell you that cylinder number two is misfiring. The trouble code does not tell you why the cylinder is misfiring. You have to figure that out by performing other diagnostic tests. The misfire that is causing the code to set may be due to a fouled spark plug, a bad plug wire, a defective ignition coil, a clogged or dead fuel injector or a loss of compression due to a leaky exhaust valve, leaky head gasket or worn cam lobe. Steve & Lynley McAfee (2002, P. 3)

Figure 4.23 Clearing of Trouble Codes after repairs



Source: Researcher's survey, 2014

Regarding clearing of the trouble codes after repairs, the outcome showing in Figure 4.23 suggest that 66% of the respondents can remove trouble codes after repairs. Meanwhile, 32% respondents reported 'No' that is they cannot remove the trouble codes after repairs.

Diagnosis of computer managed vehicles involves investigating the problem, rectifying the problem and after which the trouble codes must be cleared. The malfunction indicator light will continue to stay on until the code is cleared before the malfunction indicator light goes off. This collaborates with Tom Denton (2006) point out that, fault codes can be cleared from the ECU memory in two ways:

- using the facilities of a fault code reader (scanner) to clear the memory;

● disconnecting the battery earth lead for about two minutes (does not always work however). The first method is clearly recommended because disconnecting the battery will also 'reset' many other functions such as the radio code, the clock and even the learnt or adaptive functions in the ECUs. Tom Denton (2006, P. 18). Clearing of Fault codes. Advanced Automotive Fault Diagnosis.

Table4.24 Knowledge of sensors monitoring the various systems and components

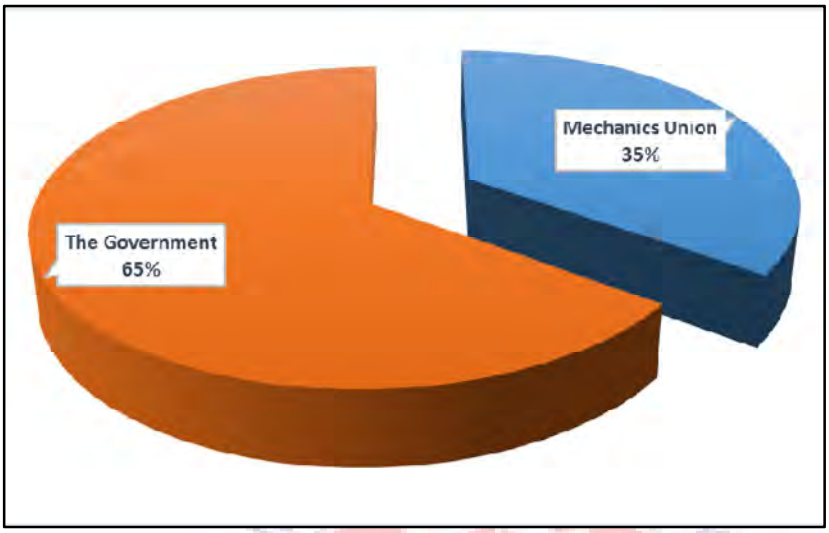
Response Items	Frequency (N)	Percent (%)
Yes	55	95
No	3	5
Total	**58**	**100.0**

Source: Researcher's survey, 2014

Table 4.24, reports that 55 (95%) of the respondents responded 'Yes' to knowing that there are sensors monitoring the various systems and components. However, only 3 (5%) of the respondents do not know this thereby responding 'No'.

In Electronic Engine Management systems the sensors served as inputs to the Electronic Control Unit (ECU) which use the input information to make operating decisions about the various conditions monitored. The above response shows that majority of the mechanics representing 95% indicated that, they are aware of sensors in vehicles which provide inputs to the ECU. This was in agreement with (Tayota sales, USA Inc.). The Electronic Control Unit (ECU) to monitor the operating conditions, utilizing information from the sensors.

Figure 4.25 Training by mechanics in the automotive repair sector



Source: Researcher's survey, 2014

In the diagram (Figures 4.25) above represents whom respondents think should organize the training. Majority responded that the Government which represents 65% should be the one to organize the training for the vehicles repairers in other to improve on repairing emission related cars. However, only 35% of the total respondent on the other hand responded that if there is a Mechanics Union then they must organize this training for it members for them to benefit from the Union that they themselves have establish if there is any.

As a result of the different technology used in automotive computer controlled systems, has lead to a paradigm shift in the inspection and maintenance in the sector. It has become necessary for the mechanics Union to partner with some of the Automobile dealers or Government to organize training periodically to upgrade their knowledge in modern vehicles. The above analysis shows that majority responded that

the Government which represents 65% should be the one to organize the training for the vehicles repairers in other to improve their knowledge in repairs of emission related cars as stated by Dietmar von (2011) revealed that training in fault diagnosis is continuously being revised to serve different automotive repair sectors. Car failure detection is a sequence of diagnostic processes that necessitates the deployment of expertise. The Expert System (ES) is one of the leading Artificial Intelligence (AI) techniques that have been adopted to handle such task. Diagnosis of car faults requires high technical skills and experienced mechanics that are typically resource and experience. The systems such as Car Failure and Malfunction Diagnosis Assistance System (CFMDAS) can be highly useful in assisting mechanics for failure detection and training purposes.

CAN IMPROVED KNOWLEDGE OF THE SYSTEMS BY MECHANICS AID IN SPEEDY AND EFFICIENT DIAGNOSTICS

Table 4.26 Exhaust gas from vehicles during maintenance affect human health

Response Items	Frequency (N)	Percent (%)
Yes	55	91.7
No	5	8.3
Total	**60**	**100.0**

Source: Researcher's survey, 2014

The Table 4.26 above gives responses on whether respondents agree that exhaust gas from vehicles during maintenance affect our health. From the figure more than two-thirds of the respondents 55 responded 'Yes' to the fact that exhaust gases from vehicles during maintenance can affect their health. However, only 5 responded 'No'.

The exhaust gas from vehicles are made up of chemicals which is poisonous to human health and from the figure above showed that, more than two-thirds of the respondents 55 responded 'Yes' to the health effects of exhaust gases. This support the assertion made by Gislason (2011) Car exhaust is toxic at ground level. Exhaust from all combustion engines combine to produce local adverse effects on the health of car users and all innocent bystanders including Technicians and Mechanics. The adverse health effects of car exhaust are pervasive and difficult to measure.(Gislason,2011, P. 3). This also collaborated with Prabhakar Pillai (2012) that, land pollution can affect the general environment of the Earth. Land pollutions leads to loss in the forest cover of Earth. This is in turn going to affect the amount of rain. Fewer rains mean lesser vegetation. The effect of all different kinds of pollution will eventually lead to problems like acid rains, greenhouse effect, global warming. All of these problems have already initiated and need to be curbed before the situation runs out of control. Prabhakar Pillai (2012). Towards this direction, a study made by Robin Odach (1987) New York City (NYC) has a significant air pollution problem that causes premature death for many people. It is caused by sunlight interacting with vapors released from motor vehicles, factories and fuel-burning sources. The American Lung Association says the NYC was ranked 16th for ozone pollution when compared to 25 other American cities. Fine particulate matter is another culprit, and it is caused by ash, soot, diesel fumes and chemical emissions. Particulates burrow their way deep into the lungs and cause asthma, chest pain, wheezing and cancer. (Robin Odach, 1987).

This also agreed with (WHO/EOS/97.08) that, the efforts to achieve sustainable development, governments worldwide are facing a growing problem of the effects on

health induced by air pollutant concentration which are caused by motor vehicle emissions.

Table 4.27 Impact of exhaust gases on the Environment

	Do the gases impact negatively on the Environment		
Rank of Respondents	**Yes**	**No**	**Total**
W/Manager	6	0	6
Forman	2	0	2
Technician	10	5	15
Mechanic	26	0	26
Apprentice	11	0	11
Total	**55**	**5**	**60**

Source: Researcher's survey, 2014

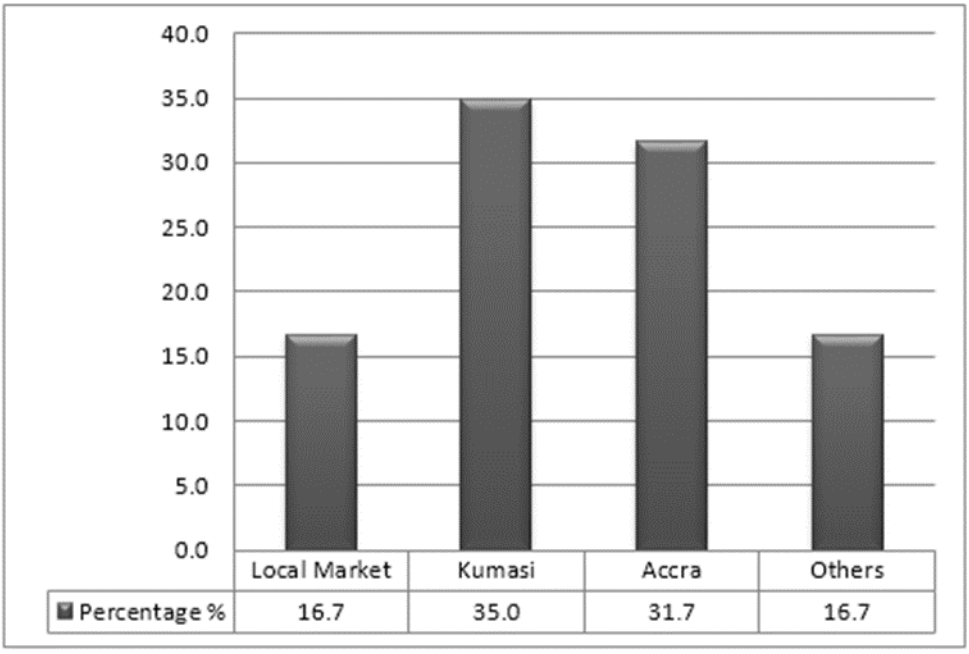
Respondents were asked whether gases impact negatively on the environment. The results showing in Table 4.27 portrays that majority of the respondents (n=55) are aware that gases released has a negative impact on the environment. However, only 5 of the respondents disagreed.

On-board diagnostics (OBD) systems were developed to help repair technicians identify problems associated with the computerized engine management systems of modern vehicles to reduce the pollution cause to the Environment. Response obtained from the respondents indicated that majority representing 91.66% agreed that the exhaust gases pollute the Environment and poses health risk to the respondents, even though they don't have protective gadgets to protect themselves. This was contrarily to report by According to Chris Korleski (2007) Technicians who carry out diagnosis on motor vehicles must be trained and certified by a U.S. EPA approved organization. Training must include instruction on the proper use of equipment, regulatory requirements, importance of refrigerant recovery and the effects of ozone depletion. To

be certified, technicians must pass a test demonstrating their knowledge in these areas. (Chris Korleski, 2007, p. 5).

According to Michael Evans (2011) it is estimated that every year various forms of transport consume between 20% and 25% of the world's energy and this significantly contributes to the increasingly high levels of greenhouse gases that continue to be released into the atmosphere. (Michael Evans, 2011).

Figure 4.28 Acquisition of spare parts for electronic controlled cars



Source: Researcher's survey, 2014

Spare parts are vital tools needed in vehicle repair business and so respondents were asked to indicate where they get their spares from. From the results showing in Figure 4.28, majority of the respondents 35% source their spare parts from Kumasi, whiles 31.7% buy their spares from Accra. On the other hand 16.7% of the respondents get spare part from the Local Market and 16.7% get their spare parts from scrub metal dealers.

Acquiring spare parts for electronic manage cars is a major problem in the Tamale metropolis. Since mechanics has to travel to Kumasi or Accra for spare parts on electronics managed cars and other components. The above analysis showed that majority of the respondents representing 35% acquires spare parts from Kumasi and 31.not7% buys their spares from Accra. This cause serious delay in the Automobile repair sector in the Metropolis

HOW RELEVANT IS EMISSION CONTROL DEVICES IN THE VEHICLE EXHAUST SYSTEM

Table 4.30 Vehicle exhaust emission control devices are relevant

Response Items	Frequency (N)	Percent (%)
Strongly Agree	45	75.0
Agree	7	11.7
Not Sure	2	3.3
Disagree	5	8.3
Strongly Disagree	1	1.7
Total	**60**	**100.0**

Source: Researcher's survey, 2014

In Table 4.30, the impression is that about two-thirds of the respondents (n=45, 75%) strongly agree that vehicle exhaust emission control devises are relevant. Also, 7 respondent comprising 11.7% agree to the statement. However, 5 respondents representing 8.3% disagree whereas only 1 respondent (1.7%) strongly disagreed to the fact that vehicle exhaust emission control devices are relevant. It is worthy of mention that 2 respondents representing 3.3% were not sure.

Allan Bonnick (2001) is of the view that, Diagnostic equipment and limitations of Diagnostic Trouble Codes (DTCs), completely new set of tools and equipments are

needed to deal with OBD II and possibly European on-board diagnostics (EOBD). If we take coolant sensor and consider the implications of the code that tells us that there is a low coolant temperature and consider what might be involved, we should see that reading the DTCs is often one of several steps on the path to diagnosis and repair of defects. Allan Bonnick(2001, p. 85-86).

Table 4.31 Defective Mass Air Flow (MAF) sensor on exhaust emission.

Response Items	Frequency (N)	Percent (%)
Strongly Agree	43	71.7
Agree	6	10.0
Not Sure	4	6.7
Disagree	4	6.7
Strongly Disagree	3	5.0
Total	**60**	**100.0**

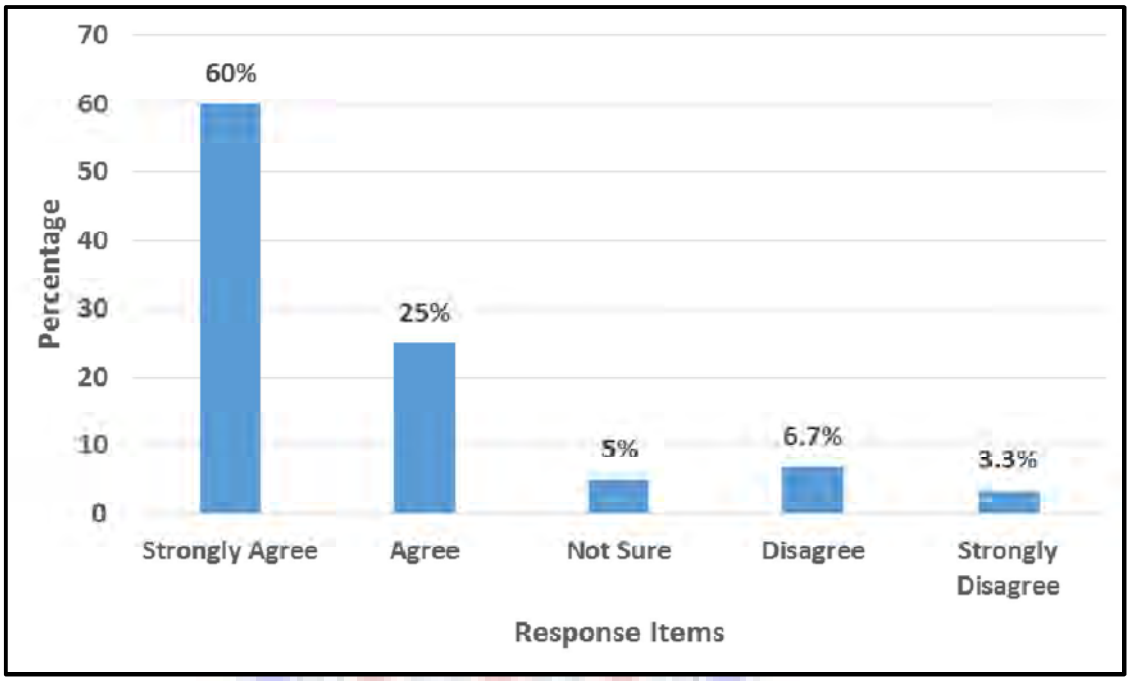
Source: Researcher's survey, 2014

On the subject of defective Mass Air Flow (MAF), the results showing in Table 4.31, majority of the respondents (n=43, 71.7%) strongly agreed that an engine with a bad mass air flow sensor can cause exhaust emissions. Also, 6 respondents representing 10% of the total respondent population agreed to the statement. However, 4 and 3 respondents representing 6.7% and 5% disagreed and strongly disagreed respectively. Four (4) respondents were not sure.

The Mass Air Flow (MAF) measures the amount of air entering the engine and malfunctioning of it will result in excessive rich mixture leading to high level of Carbon Monoxide (CO) and lean mixture will also lead to high level of Nitrogen Oxides (NOx) which are emission related gases. Mark Davidson (2013) explains that, Mass air flow sensor is used by the control module to measure the volume of air

entering the engine. The control module uses this information to calculate fuel delivery. The typical Mass air flow (MAF) sensor contains a mesh screen to break up air flow and prevent debris from entering the sensor. Mark Davidson (2013)

Figure 4.32 Exhaust gases from Automobile have effect on the inhabitants in the Metropolis

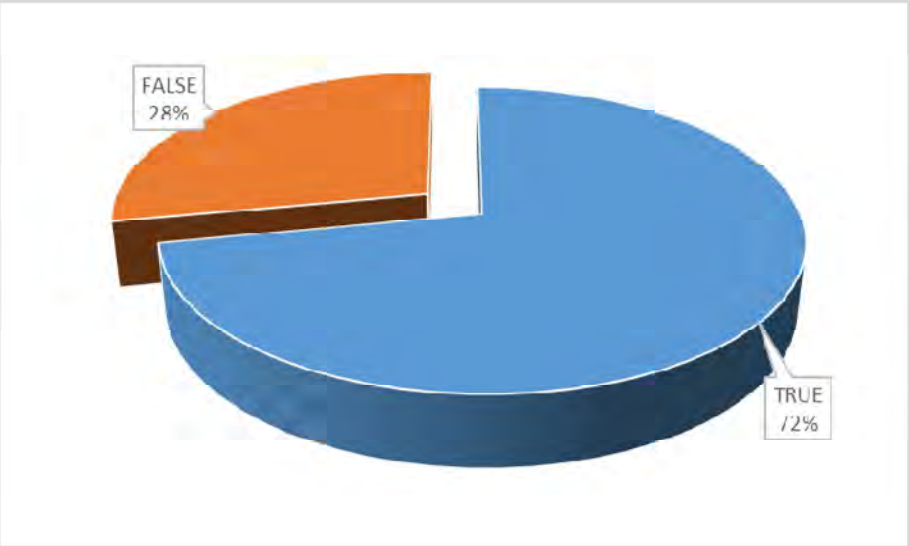


Source: Researcher's survey, 2014

Figure 4.32 above shows responses on whether exhaust gases from automobile have effect on the inhabitants in the Metropolis. The figure shows that 60% of the respondents strongly agreed that exhaust gases from automobiles have effect on the inhabitants. Moreover, 25% agreed to that effect. On the other hand, 6.7% disagreed and another 3.3% strongly disagreed that exhaust gases from automobiles have effect on the inhabitants in the metropolis. The vehicular emission is of great concern to most countries across the world this can only be reduced through proper inspection and diagnosis by mechanics. As the number of vehicles in the country continue to increase

yearly. As could be discerned from the data analysis majority of the respondents agreed that the exhaust gases have effect on the health of the inhabitants of the Metropolis. This supports the study made by Willard W. Pulkrabek (2009) the exhaust of automobiles is one of the major contributors to the world's air pollution problem. Recent research and development has made major reductions in engine emissions, but a growing population and a greater number of automobiles mean that the problem will exist for many years to come. During the first half of the 1900s, automobile emissions were not recognized as a problem, mainly due to the lower number of vehicles. As the number of automobiles grew along with more power plants, home furnaces, and population in general became an ever-increasing problem. During the 1940s, the problem was first seen in the Los Angeles area due to the high density of people and automobiles, as well as unique weather conditions. By the 1970s, air pollution was recognized as a major problem in most cities of the United States as well as in many large urban areas around the world. Laws were passed in the United States and in other industrialized countries which limit the amount of various exhaust emissions that are allowed by Automobile Vehicles. This put a major restriction on automobile engine development during the 1980s and 1990s. (Willard W. Pulkrabek 2009 P.30).

Figure 4.33 Positive Crankcase ventilation reduces vehicle exhaust emission problems



Source: Researcher's survey, 2014

Figure 4.33 above, shows that about two-thirds of the respondents 72% responded 'True' to the fact that positive crankcase ventilation reduces vehicle exhaust emission problems. On the other hand, 28% responded 'False' to that effect. Positive crankcase ventilation is part of the measures to reduce vehicular pollutants. As Explained by McAfee (2012) and lance wright (2013) that Positive crankcase ventilation is a system allows fresh air through the crankcase to sweep out blowby and fuel vapour into the inlet side of the engine to prevent emission and mechanics should not ignore this important feature. The above, shows that about two-thirds of the respondents 72% responded 'True' to the fact that positive crankcase ventilation reduces vehicle exhaust emission problems. This agreed with Steven The air enters the engine where the pollutants from the crankcase have another chance to burn to reduce emission.

Table 4.34 Exhaust Gas Recirculation reduce vehicle emission problems

Response Items	Frequency	Percent
Strongly Agree	19	31.7
Agree	14	23.3
Not Sure	4	6.7
Disagree	14	23.3
Strongly Disagree	9	15.0
Total	**60**	**100.0**

Source: Researcher's survey, 2014

Table 4.34 above shows there were a nearly divided opinion on the subject of exhaust gas recirculation. The table indicates that majority of the respondents (n=19, 31.7%) strongly agreed, also, 14 respondents making up 23.3% agreed that exhaust gas recirculation reduce vehicle emission problems. On the contrary, 14 respondents comprising 23.3% disagreed whereas 9 respondents representing 15% disagreed strongly. However, 4, respondents being 6.7% were not sure.

At very high temperatures the exhaust gas is recirculated into the inlet manifold to reduce emission of nitrogen oxides (NOx) and the above analysis shows that the Mechanics are aware of exhaust gas recirculation in reduceing vehicle emission problems. This finding supports what Derek Newbold and Allan Bonnick, (2005, P. 101) Exhaust gas recirculation (EGR) valve play an important role in reducing emissions of Nitrogen Oxides (NOx), if combustion chamber temperatures do not rise above normal operating temperature, because it is the temperature at which NOx can be produced. Exhaust gas recirculation helps to keep combustion temperatures low by recirculating a limited amount of exhaust gas from the exhaust system, back to the induction system. In order to provide good performance, EGR does not operate when

the engine is cold or when the engine is operating at full load. Under reasonable operating conditions, it is estimated that EGR will reduce NOx emissions by approximately 30%. Derek Newbold and Allan Bonnick, (2005, P. 101)

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

The main objective of the study is to evaluate the effects of pollution cause by Automobile Diagnosis on the Environment in the Tamale Metropolis of Northern Region of Ghana, taking cognizance of the knowledge of the Mechanics, technicians and Managers of Automobile workshops in the Metropolis.

The researcher adopting the non-probability sampling method of random sampling, specifically the purposive sampling technique. Total number of questionnaires administered was sixty (60) to the mechanics, Technicians and Managers of Automobile workshops to assess the effects of Environmental pollution in that sector.

The study also summarizes the findings made and draws conclusions from the findings. It also presents recommendations that would help to address some of the problems of Effects of Automobile Diagnosis on Environmental pollution in the Tamale Metropolis of Northern Region of Ghana and suggestions for future research.

5.1 Summary of Findings

The study revealed that, the educational level of majority of the Mechanics, Technicians and the Automobile Workshop Managers in this sector were vocational/ technical, O level/SHS and junior secondary school graduates, which made up of the following percentages (n=28, 46.7%) , (n=5, 8.3%) and (n=7, 11.7%) respectively. Apart from formal education, (n=41, 68.3%) Mechanics, Technicians and the Automobile Workshop Owners in this sector do not have opportunity to attend any

training on how to use modern Diagnostic Equipments and the Effects of pollution as result of their activities on the Environment.

The study also revealed that 54 comprising 90% of the respondents agreed to the fact that Education will facilitate the understanding of Mechanics and Technicians in diagnosing modern Electronics Managed Vehicles. In addition, (n=53, 88.0%) of the respondents responded 'Yes' to the facts that, it is important to have some knowledge of the systems when diagnosing vehicles with Electronic Engine Management systems. In addition, majority (n=54, 90%) of the Mechanics, Technicians and the Managers of Automobile workshops do not use workshop manuals. Moreover, the (n=6, 10%) even though they have repair manuals, they don't use them.

Significant numbers of the Mechanics, Technicians (n32, 53%) do not have training on the emission related cars. Out of the (60) respondents, Majority (n39, 65%) agreed that the Government should organize the training for the vehicles repairers in other to improve their knowledge on emission related cars. However, only 35% of the total respondent on the other hand responded that, the Mechanics Union must organize this training for it members for them to benefit from the Union that they have established.

Respondents also agree that exhaust gas from vehicles during maintenance affect our health. More than two third of the respondents (91.7%) indicated that exhaust gases from vehicles during maintenance can affect their health.

The results also portrays that majority of the respondents (n=55) accepted that, the gases released during maintenance has a negative effect on the environment. The study

also observed that, majority of the respondents (35%, 31.7%) acquires spare parts from Kumasi and Accra. On the other hand 16.7% of the respondents get spare part from the Local Market and 16.7% get their spare parts from scrub metal dealers.

Furthermore, significant number of the workshop Mechanics and the Technicians (95%) indicates that the check Engine Light is a warning signal which comes on when emission related systems or components are faulty. Workshop managers and mechanics show that 52 respondents comprising 87% of total respondents responded 'Yes' to always checking the dash board for the Check Engine Light. However, only 8 respondents being 13% responded 'No to the effect that, they don't always check the dash board panel during diagnosis.

5.2 Conclusions

The study has shown that the educational level of majority of the Mechanics, Technicians and the Managers of Automobile workshop owners in this sector was certainly low. Owing to this, majority do not deem it necessary to read Automobile repair manuals on the use of Diagnostic Equipments and service bulletins of new vehicles. These could result to Environmental pollution through improper Diagnosis. The Mechanics and Technicians in the various workshops do not have opportunity to attend any further training on how to Diagnose and fix problems in order to prevent emission as a result of the activities in that sector.

The Automobile workshop owners and the Mechanics in the Tamale Metropolis lack basic modern Diagnostic Equipments to be able to carry out effective Diagnosis on electronics managed vehicles in their shops.

The Automobile workshop owners, Technicians and Mechanics are ignorance of the health effects of Automobile exhaust on the inhabitants, as well as its Environmental consequences as fleet of vehicles in the Tamale Metropolis continue to increase.

5.3 Recommendations

The following recommendations made were in the light of the findings and conclusions drawn from the study and when successfully implemented would improve the knowledge of Technicians and Mechanics in diagnosing and fixing problems on vehicles with Electronic Engine Management Systems in the Tamale Metropolis.

- The Department of Factories Inspectorate (DFI) and Ghana National Association of Garages (GNAG) should organize intensive and effective education and training for members of Automobile workshop owners and Mechanics on Exhaust Emission in their workshops.
- Roadside mechanics in the Tamale Metropolis have very little diagnostic knowledge about the electronic managed vehicles coming into the Tamale Metropolis and the need to acquire knowledge in the fast growing industry to help reduce the Environmental pollution and the heath risk associated with it. They however recognize this fact and are willing to lean.
- The Ghana National Association of Garages (GNAG) should organize intensive training on basic knowledge of how the various systems in the Automobile vehicle are functioning.
- The Automobile Garages should form partnership with the big Automobile companies to supply the needed spare parts for most of the Electronic Manage

Vehicles and made them sufficiently availability in stores to reduce procurement time in travelling to Kumasi and Accra.

- The Technicians and Mechanics in the Tamale Metropolis have very little diagnostic knowledge about the electronic managed vehicles coming into the system and the need to train them acquire up to date knowledge in the fast growing industry. They however recognize this fact and are willing to lean.
- It is a recognized fact that the Mechanics and the Technicians need a lot of financial support to be able to acquire the needed diagnostic equipments, such as Diagnostic Computers, Scan Tools, and Multimeters to be able to work efficiently.
- In addition to the financial support, it was also realized that the Mechanics and Technicians who are trainable need some assistance in the form of skill training periodically that will help them to upgrade their skills According to the study they look up to the government, non-governmental organizations, Automobile Repair Garage Unions and training Institutions such as the University of Education, Winneba (UEW), Kumasi or the Polytechnics, Technical and Vocational Institutions for members in the Tamale Metropolis.
- Environmental Protection Agency (EPA) should organized Education Programmes to Educate them on the need to reduce the Exhaust Pollution.
- Environmental Protection Agency (EPA) should also visit the Automobile Workshops periodically to ensure that, the Emission Laws are not abused.

5.4 Suggestions for Future Research

This research can be replicated by increasing the sample size and using the whole of the small-scale of Automobile Repair workshops in the Tamale Metropolis.

The research should include, the Tri-cycle motor bikes and the stationary plants should be considered.

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APPENDIX

UNIVERSITY OF EDUCATION, WINNEBA- KUMASI

M-TECH MECHANICAL TECHNOLOGY EDUCATION

QUESTIONNAIRE FOR AUOMOTIVE WORKSHOP MANAGERS AND MECHANICS

PREAMBLE

The researcher is a student of University of Education, Winneba-Kumasi who is writing a project on In-Efficient diagnosis of vehicles by Automobile repair workshops. The Environmental and health hazards associated with it and also look at the knowledge level in diagnosing vehicles in order to meet the Environmental Protection Agency (EPA), the Regional Factory Inspectorate Division and the Vehicle and Driver License Authority. It has become necessary to seek your candid views on some issues relating to the topic through this questionnaire. Please indicate your view on each statement by ticking [ ] in the appropriate column, the response that suits the extent to which you agree with the statement. Please be assured that your responses would be kept highly confidential. Thank you very much for the anticipated co-operation.

SECTION A: BASIC DATA

Age of the respondent

31-40 [ ] 41-60 [ ]

Rank of the respondent

W/Manager [ ] Forman [ ] Technician [ ] Mechanic [ ]
Apprentice [ ]

Sex of the respondent

Female [ ] Male [ ]

Educational level of the respondent

Technical/vocational [ ] O level/SHS [ ] JHS [ ] Primary [ ]

How long have you been in the repair industry?

Less than a yr [ ] 1-2 yrs [ ] 3-4 yrs [ ] 5-6 yrs [ ] more [ ]

Name of the organization……..

SECTION B

1. What type of vehicles do you repair?

(1) Heavy duty vehicles [ ] (2) Light duty vehicles [ ] (3)Cars [ ]

2. How many skilled mechanics do you have in your workshop?

(1)1 [ ] (2) 2 [ ] (3) 3 [ ] (4) More [ ]

3. How many unskilled mechanics do you have?

(1) 1[ ] (2) 2 [ ] (3) 3 [ ] (4) More [ ]

1. Are you aware of that vehicles coming into Region are now equipped with emission control devices?

   Yes [ ] No [ ]

2. Are you aware of the **check Engine** light?

   Yes [ ] No [ ]

   Do you know that it is a warning signal?

   Yes [ ] No [ ]

3. Do you always check the dash board panel for the check engine light in diagnosis?

   Yes [ ] No [ ]

6. Do you need training on the emission manage cars?

   Yes [ ] No [ ]

   Who do you think should organize the training?

   The government [ ] mechanics union [ ]

8. Do you have modern Diagnostic Equipment?

   Yes [ ] No [ ]

9. Did you have any training on how to use the Diagnostic Equipment?

   Yes [ ] No [ ]

10. Do you have knowledge on the emission manage components?

    Yes [ ] No [ ]

11. Have you ever received training on the emission managed cars?

    Yes [ ] No [ ]

12. Was it through an organization?

    Yes [ ] No [ ]

13. How do you acquire spare parts for electronic manage cars?

(1) Local market [ ] (2) Kumasi [ ] (3) Accra [ ]

14. Do you know that loose harness connector can cause **check Engine** light to come on?

Yes [ ] No [ ]

15. Do you know that there are trouble codes?

Yes [ ] No [ ]

18. Can you interpret the trouble codes?

Yes [ ] No [ ]

Do you know that the diagnostic trouble codes have meaning?

Yes [ ] No [ ]

16. Do you know that **the check Engine** light can be used to retrieve On-Board Diagnosis 1 (OBD) I trouble codes?

Yes [ ] No [ ]

17. Do you know that short circuiting can damage electronic components?

Yes [ ] No [ ]

18. Do you know that disconnecting the battery terminals on OBD I cars can turn off check Engine light?

Yes [ ] No [ ]

20. Do you know that cutting wires in the emission manage cars can lead to total malfunctioning?

Yes [ ] No [ ]

21. Do you know how to clear trouble codes after repairs?

Yes [ ] No [ ]

22. Do you have repair manuals?

Yes [ ] No [ ]

23. If yes, do you refer to the manuals during repairs?

Yes [ ] No [ ]

24. Do you think Education will aid in your diagnosis?

Yes [ ] No [ ]

25. Is the road network in the Region affecting the emission managed cars?

Yes [ ] No [ ]

26. Do you consult each other on repairs of emission manage cars?

Yes [ ] No [ ]

27. Do you keep records on every car that you repair?

Yes [ ] No [ ]

28. Do you have a maintenance schedule for servicing your customer's cars?

Yes [ ] No [ ]

29. Do you make follow up of customers after repairs?

Yes [ ] No [ ]

30. Do you have returned jobs on emission manage cars?

Yes [ ] No [ ]

31. Do you know that some levels of understanding of the system is required in diagnosing modern vehicles?

Yes [ ] No [ ]

32. Do you know that there are sensors monitoring the various systems and components?

Yes [ ] No [ ]

33. Do you educate your mechanics on the emission related issues?

Yes [ ] No [ ]

34. Does Education plays a central part in diagnosing emission manage vehicles?

Yes [ ] No [ ]