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Environmental Impacts of Automotive Air Conditioning System Maintenance Practices Embraced by Service Technicians in Niger State, Nigeria

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Abstract: This research work examined the environmental impacts of automotive air conditioning system maintenance practices embraced by service technician in Niger State, Nigeria. The study sought out the problem associated with automotive air conditioning maintenance practices and the way of improving automotive air conditioning system maintenance practices by automotive air conditioning services technicians in Niger State. Two research questions and two hypotheses guided the study. A descriptive survey research designed was adopted for the study. A total population of 155 respondents comprises of 97 highly experienced registered air conditioning service technicians and 58 moderately experienced registered air conditioning service technicians in Niger State. The respondents were selected according to the year of service, which was 1-14 years for moderately experienced and 15 above for highly experienced service technicians. Due to manageable sizes of the respondents, the entire population was used i.e no sampling techniques was utilized for the study. A structured questionnaire title "Automotive Air Conditioning System Maintenance Practices Questionnaire" was used validated by three experts (one lecturer from Department of Industrial and Technology Education, Federal University of Technology Minna, one expert from Ministry of Environment Niger State and one expert from Ministry of Health Niger State). The questionnaire was pilot tested using 30 automotive air conditioning service technicians from Abuja. The data collected were analyzed using Cronbach Alpha Statistics and its yielded to 0.71 reliability coefficient. Mean and standard deviation were used to analyze the research questions and hypotheses were tested at 0.05 level of significance using z-test statistics. The numerical values obtained from the responses of the respondents were tabulated and analyzed using statistical package for social science (SPSS) version 21. The findings among other revealed that inhalation of concentration refrigerant vapour is dangerous and can be fatal, exposure to level of fluorocarbons above recommended exposure levels can results in loss of concentration and drowsiness, inhaling refrigerants adds to the effect of chronic illness. It is recommended amongst other that hazardous automotive air conditioning waste generated by automotive service technicians' shops should always be removed by licensed personnel under the supervision of environmental agencies. Manufacturer instructions on refrigerants should be followed by technicians.

Keywords: *Automotive air conditioning, Environmental impact, Nigeria, Refrigerant, Service technicians*

Conflicts of interest: None
Supporting agencies: None

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1. Introduction

Automotive air conditioning system is a set of components that function together in order to emit coolness to a vehicle's interior. Nishant and Ekhlak (2018) explained that automotive air conditioning is the process by which the air is cooled and cleaned, the humidity lowered and the air circulated. The quantity and quality of the air is also controlled. Under ideal conditions the air-conditioning system can be expected to accomplish all these tasks at the same time. The automotive air

conditioner in the context of this study functions as the mechanism to transfer heat from a vehicle to the surrounding. The automotive air-conditioning system works by manipulating refrigerant between a liquid and a gaseous state.

Most automotive air conditioning refrigerants are known to have negative effects on the environment since they contributes to global warming and ozone layer depletion. Greenhouse gases like carbon dioxide and emissions from some refrigerants contributes to global warming by absorbing infrared radiation and holding it in the atmosphere. Ogunleye et al., (2021) postulated that refrigerant is a fluid capable of changes of its state at low temperatures. Vandana and Gupta (2015) explained that natural refrigerants such as hydrocarbons, ammonia, and carbon dioxide have good thermodynamic fluids for a vapor compression system because they have large latent heats of vaporization which yield lower refrigerant flow rates and have low pressure drops because of their properties. Refrigerant 12 (R-12) according to Adegun and Ohawa (2016) is ideal for automotive use because of its relatively low operating pressures, as compared to other refrigerants. The author further explained that R-12 does not react with most metals such as iron, aluminum, copper or steel, however, some refrigerant that appears to be toxic of flammable could be made useful for systems larger than a refrigerator, it is necessary to reduce their charge below the levels necessary to warrant a toxic or flammable situation in the case of a system leak (Mohan et al., 2019). Another constraint introduced with the reduction of charge in a system, is the maintaining of a base line thermal performance of the system including capacity, compressor power, and Coefficient of Performance (COP).

Refrigerant 12 (R-12) according to Vandana and Gupta (2015) argued that since tubes and components through which R-12 used in automotive air conditioning system passes through are made smaller, there is every tendency for capacity and COP to suffer due to a high pressure drop and this may results into a development of a technical problems of the entire system which may impacts the environment negatively. Minimizing the environmental impacts of automotive air conditioning system can reduce harmful effects on the health, safety and productivity of staff, environmental prosecutions and fines, damage of business reputation, expensive clean- up costs and other business benefits which require the attention of a service technicians.

Service technicians are skilled workers that can operate in variety of industries to provide services and repairs. Ogunleye et al., (2021) postulated that service technicians are responsible for providing difference services, depending on their area of expertise, and diagnosing problems and making repairs. Service technicians in the context of this study are those individual that are responsible for the installation, maintenance, or repair of different units related to automotive air conditioning systems. The service technicians in the context of this study are further classified as highly experienced service technicians and moderately experienced service technicians, their year of service in the job is a major factor considered for these classification. For instance, for those of them who have been in this job 1-14 years are termed moderately experienced and those with 15-25 years are termed highly experienced. Hence they are in better position to respond to the issued raised for this study. Automotive Air Conditioning (AC) Service technicians have the potential of becoming sick, ill and disable for life because of their exposure to a variety of health hazards through pollution which can leads to skin cancers, cataracts, eyes problems, weakened immune systems. The automotive air conditioning servicing and repairing industry can plays an important role in reducing pollution by ensuring that automotive air conditioning are operating efficiently and by extending air conditioning life through routine maintenance.

Maintenance is the action performed to keep machine or equipment functioning or in-service. Adeyeri (2017) defined maintenance practices are practices of high quality aimed at increasing machines performance with improved/ enhanced functionality of parts using safe, secure technologies and methods utilizing optimal resources by reducing or eliminating machine downtime, Mean Time To Repair (MTTR) and products' wastes thereby providing maximum usability and reusability of parts / components, enhanced production benefits, economic impact and making the enterprise to stand competitively. Maintenance activities can influence the entire manufacturing/production operation, from product quality to on-time delivery records and its effect on the environment. Good maintenance practices in automotive air conditioning systems can cut production costs immensely, well beings of AC technicians and environment whereas poor maintenance procedures in air conditioning system leads to illness of technicians, affecting the environment and can also cost a company millions of naira to effect repairs and correct poor quality and production lost. In a bid to correct and reduce these menaces, it is on this basis that the study is designed to identify the environmental impacts of automotive air conditioning system maintenance practices embraced by service technicians in Niger State, Nigeria.

Automobile air conditioning maintenance practices protect the service technicians from over exposure to refrigerants, keep the environment clean and fresh, global warming as well as reduction in environmental pollution that may arise from haphazard handling of automotive air conditioning refrigerants. However, it has been observed by Adedokun and Audu (2019) that the rate at which mechanics handles waste is indecent, which also noticed by the researcher the manner at which air conditioning technicians handles and disposes refrigerants and other related wastes in Niger State is on the increase. Vandana and Gupta (2015) reported that many of these refrigerants are not only harmful and potentially life threatening but appears to be also flammable and should not be disposed indiscriminately because its increases the Ultraviolet (UV) Radiation in ozone layer.

A diminished ozone layer allows more radiation to reach the Earth's surface. For people, overexposure to UV rays can lead to skin cancer, cataracts, and weakened

[illegible]

2. Relevant Literatures

2.1 HFO-1234yf health hazards

[illegible]

2.2 Hydrofluorocarbon (HFC) blends health hazards

[illegible]

2.3 Hazards to human health

[illegible]

i. Leaks or spills from the refrigeration system,
ii. The electronic appliances recycling system, and
iii. Cleaning and gas delivery pipelines (Tsai, 2005).

2.4 Strategies for effective management of automotive air conditioning and refrigeration handling and recycling

There are different strategies for effective management of automotive air conditioning and refrigeration handling and recycling which discussed by different researchers such as:

a) Selection of refrigerant
b) Workers health and safety (Refrigeration, Air Conditioning Heat Pump Technical Option Committee, RTOC, 2018).

Selection of refrigerant

Refrigerant selection is a balanced result of several factors that should be considered when selecting an alternative refrigerant for refrigeration, air conditioning and heat pump systems and applications. [illegible]

[illegible]

Workers health and safety

a. Manufacturing workers [illegible]

b. Refrigerant workers [illegible]

c. Recycling and reclamation workers [illegible]

charging. From consultation with a reclaimer, if the recovered refrigerant material is not suitable for re-processing, the material must be treated at an approved waste treatment facility.

3. Materials and methods

The study was conducted in all the motor vehicles workshops that house the automotive air conditioning system service technicians in Niger State. Niger State is situated in the North-Central Geopolitical Zone of Nigeria with a total land mass of 86,000km2; approximately 8.6 million hectares constituting about 9.3% of the total land area of the country. Lying on latitude 3.200 East and longitude 11.300 North, the State shares a country border with the Republic of Benin (West) and State border within Nigeria, these include the Federal Republic Territory (FCT) on the South East, Zamfara (West), Kebbi (North West), Kwara (South West) andKaduna (North East). The targeted population for the study was 155 respondents comprising of 97 highly experienced and 58 moderate experienced registered automotive air conditioning system service technicians in Niger State (NATA, 2021). Since the population was of manageable size, the entire population was study; hence no sampling technique was employed for the study. Mean and standard deviation were used to analyze the two research questions while z-test statistics was used to test the null hypotheses at 0.05 level of significance.

4. Results

Table 1 shows the mean responses of the respondents on the 18 items posed to determine the problems associated with automotive air conditioning maintenance practices with a grand mean of 4.63 which implies that the automotive service technicians highly embraced with the majority of items as problems associated with automotive air conditioning maintenance practices. The standard deviation of items ranges from 0.24 to 0.61. This standard deviation showed that the respondents were not too far from the mean and were closed in one another into their responses. This closeness of the responses adds values to the reliability of the item.

The analysis of the result of table 2 shows that the respondents embraced all items as regards to the ways of improving automotive air conditioning maintenance practices. This evident from the mean results which shows that the items indicated have their average mean not less than 3.50 and not more than 5.00. This implies that all items presented in the table are the ways of improving automotive air Conditioning System Maintenance Practices in Niger State Nigeria and these were out of highly embraced. The Standard Deviation (SD) value of the 25 items in the table 4.6 ranges from 0.00 to 0.50, this signified that the respondents were closer to each other in their responses to the items

Hypothesis: There is no significant difference in the mean responses of highly experienced automotive air conditioning service technicians and moderately experienced automotive air conditioning service technicians on problems associated with the maintenance practice of automotive air conditioning.

Table 3 shows the z-test analysis of differences in the responses of Registered Highly Experienced Automotive Air Conditioning Service Technicians and Registered Moderately Experienced Automotive Air Conditioning Service Technicians in Niger State as regards the problem associated in the maintenance Practices of Automotive air Conditioning System. The table reveals that the probability value obtained was found to be 0.007 which is less than the probability value of 0.05 in comparison. The null hypothesis was therefore rejected. Therefore, there was significant difference in the mean responses of highly experienced automotive air conditioning service technicians and moderately experienced automotive air conditioning service technicians as regards the problem associated in the maintenance Practices of Automotive air Conditioning System in Niger State.

Hypothesis: There is no significant difference in the means responses of highly experienced automotive air conditioning service technicians and moderately experienced automotive air conditioning service technicians on ways of improving automotive air conditioning system maintenance practices

Table 4 shows the z-test analysis of differences in the responses of Registered Highly Experienced Automotive Air Conditioning Service Technicians and Registered Moderately Experienced Automotive Air Conditioning Service Technicians in Niger State as regards the ways of improving automotive air Conditioning System Maintenance Practices. The table reveals that the probability value obtained was found to be 0.060 which is greater than the probability value of 0.05 in comparison. The null hypothesis was therefore accepted. Therefore, there was no significant difference in the mean responses of highly experienced automotive air conditioning service technicians and moderately experienced automotive air conditioning service technicians as regards the ways of improving automotive air Conditioning System Maintenance Practices in Niger State.

Table 1: Mean responses and standard deviation regarding the problems associated with automotive air conditioning system maintenance practices

S/N	Items	X_1	SD_1	Remark
	Problem associated			
1	Unskillful AC technicians causes faulty installation, poor service procedures and inadequate maintenance.			

	Inhalation of concentration refrigerant vapour is dangerous and can be fatal	4.62	0.48	Highly Embraced
2	Exposure to level of fluorocarbons above recommended exposure levels can results in loss of concentration and drowsiness.	4.50	0.50	Highly Embraced
3	Improper handling and recycling leads to skin irritation, frostbite and serious eye irritation	4.41	0.50	Embraced
4	Improper handling and recycling of refrigerants leads breathing problem	4.53	0.51	Highly Embraced
5	Illness and constant fatique are experienced when handling and recycling refrigerants	4.59	0.47	Highly Embraced
6	HFO blend R-448A at high concentration can cause irregular heartbeat to technicians	4.60	0.49	Highly Embraced
7	Inhaling refrigerants adds to the effects of chronic illness	4.75	0.39	Highly Embraced
8	Improper release affects terrestrial and aquatic ecosystem	4.76	0.43	Highly Embraced
9	Global warming is contributed to by the emission of manmade "greenhouse" gases as a result of handling and recycling refrigerants	4.43	0.61	Embraced
10	Global warning causes the temperature in the atmosphere to rise and has effect on climate	4.57	0.37	Highly Embraced
11	Direct exposure to HFO-1234yf, HCF-134a, and other refrigerants exposing to loss or reduce the life span of A/C technicians	4.79	0.44	Highly Embraced
12	Attempting to recycle impure or contaminated refrigerants can damage your refrigerant recovery and recycling system	4.59	0.49	Highly Embraced
13	When the filter in the air conditioning and refrigerating is inactive, it exposes the air conditioning and refrigerating user to risk	4.72	0.35	Highly Embraced
14	Different formulations could affect the performance of the refrigerant handling, recovery and recycling	4.57	0.49	Highly Embraced
15	Inhabitants in tropical and subtropical urban areas are at especial risk due to high population density, high temperatures.	4.69	**0.42**	**Highly Embraced**
16	Over exposure to ultraviolet (UV) Radiation can lead to skin cancer, cataracts and weakened immune systems	4.89	0.24	Highly Embraced
17	Ozone layer depletion allows more UV radiations which can also lead to reduction of crop yield, disruptions in the marine food chain and other harmful effects	4.82	0.25	Highly Embraced
18	**Grand Total Mean/SD**	4.53 **4.63**	0.50 **0.44**	Highly Embraced **Highly Embraced**

N= numbers of respondents, XT = mean of all respondents, SDT = average standard deviation. highly embraced (5), embraced (4), moderately embraced (3), not embraced (2) and undecided (1)

Table 2: Mean responses and standard deviation of respondents as regards the ways of improving automotive air conditioning system maintenance practices.

		N_T=152		
S.N.	Items	X_T	SD_T	Remark
1	The work area should be ventilated when dispersing vapour	4.63	0.48	Highly Embraced
2	Fan or blower should be use in confine area for the dispersion of vapour	4.49	0.50	Embraced
3	Available vapour or oxygen should be tested by refrigerant leakage detector or equipment for monitoring oxygen	4.42	0.49	Embraced

	Technicians should follow certain precautions when working with refrigerants to ensure the safety of themselves and their customer	4.52	0.51	Highly Embraced
	Government should make public enlightenment on the health implication of improper handling, recycling of refrigerants	4.58	0.47	Highly Embraced
	Replacing refrigerants that are hazardous in native with the ones that are more environmentally friendly.	4.60	0.49	Highly Embraced
	All refrigerant that cannot be recycled onsite must be collected and shipped to an authorized facilities for reclamation	4.75	0.40	Highly Embraced
	Prohibiting the use of fluorinated greenhouse gases with a global warming potential higher than 150	4.75	0.43	Highly Embraced
	Certification requirement for refrigerant evacuation to maximize recovery of Ozone depletion substances (ODS)s during the disposal of refrigeration	4.42	0.62	Embraced
	Before handling and recycling any refrigerants, personnel should be familiar with safety concerns for the specific product with which they are working	4.56	0.37	Highly Embraced
	Always use with adequate ventilation to improve the circulation of oxygen	4.78	0.45	Highly Embraced
	Ensure that there is pressure relief valve between valve to release trap liquid refrigerants	4.59	0.49	Highly Embraced
	Use an alcohol spray to clean refrigerant sight glasses that have become coated with ice.	4.72	0.35	Highly Embraced
	When leak testing a system, use nitrogen for increasing the pressure after the refrigerant is recovered.	4.58	0.49	Highly Embraced
	Never use oxygen or compressed air for pressurization (some refrigerants may explode when under pressure and mixed air)	4.69	0.42	Highly Embraced
	People affected from refrigerants Overexposure should not be treat by Physicians using expinephrine.	4.89	0.21	Highly Embraced
	Government should organize seminars on problem solving skills for scrap recyclers and technicians	4.82	0.25	Highly Embraced
	Government should formulate a medical body that will be educating the technicians on handling and recycling of refrigerant at least twice in a year	4.54	0.49	Highly Embraced
	Government should develop or strengthen air standard enforcement capacity	5.00	0.00	Highly Embraced
	Government should improve monitoring of traditional and trace pollutant emissions and concentration.	4.69	0.46	Highly Embraced
	Avoiding mixing refrigerants when refilling gases	4.74	0.25	Highly Embraced
	Instilling disciplinary measures on problematic staffs or members should be care by their association	4.57	0.49	Highly Embraced
	Putting measure in place to prevent problem from occurring by then association	4.69	0.42	Highly Embraced
	Strengthen existing environmental guidelines and standards and develop new ones where necessary in order to counter the increasing level of emissions	4.89	0.21	Highly Embraced
	Automotive refrigerants should not be vent into the air	4.82	0.25	Highly Embraced
	Grand Total Mean /SD	**4.67**	**0.40**	**Highly Embraced**

Table 3: z-test analysis of significant difference in the mean responses of the respondents as regards the problem associated in the maintenance practices of automotive air conditioning

Automotive air conditioning service technicians	N	Mean	S.D	df	Z	P-value	Remark
Highly Experienced Service Technicians	97	4.65	0.11				

Moderately Experienced Technicians	Service	55	4.60	0.10	150	2.75	0.01	Rejected

Table 4: Z-test analysis of significant difference in the mean responses of the respondents as regards the ways of improving automotive air conditioning system maintenance practices in Niger State

Automotive air conditioning service technicians		N	Mean	S.D	df	Z	P-value	Remark
Highly Experienced Technicians	Service	97	4.68	0.10	150	1.89	0.06	Accepted
Moderately Experienced Technicians	Service	55	4.65	0.08				

5. Discussion

The Findings in Table 1 relating to research question 1 revealed that inhalation of concentration refrigerant vapour is dangerous and can be fatal, exposure to level of fluorocarbons above recommended exposure levels can results in loss of concentration and drowsiness, inhaling refrigerants adds to the effect of chronic illness. Refrigerants such as HFO blend R-448A, HFO-1234yf, HCF-134aeceteraare also listed as a possible skin or eyes irritant, can cause frostbite, at high concentrations can cause an irregular heartbeat and cause as asphyxiation in confined spaces. These effects are listed as being common for many refrigerants (United State Environmental Protection Agency, 2014). Tsai, (2005) argued that exposure to HFCs such as leaks or spills from the refrigeration system exposure, the electronic appliance recycling system; and Cleaning and gas delivery pipelines affect the health of workers who works on the refrigeration system

The Findings in Table 2 relating to research question 2 showed that the respondents agreed good knowledge of potential hazards of chemicals in the shop and how to respond to spills, leaks and other emergencies; making sure chemicals including paints, solvents, and other toxic substances are not poured on the ground or waterways; replacing materials that are hazardous in nature with more environmentally alternatives; and storage of automotive liquid waste according to the manufacture's requirements are very essential. This is because the improperly handled chemicals used in automotive workshops can seriously affect human and the environment. In support of this assertion FETA (2015) reported that improperly managed automotive waste perpetuates and aggregates environmental and health challenges already being experienced by developing countries particularly Nigeria. The findings are also in agreement with Pennsylvania Department of Environmental Protection (PDEP)(2015) which reported that the impact of waste from automotive can be reduce if automotive industries should make minimum use of material that are non-hazardous through the application of more efficient technologies. The findings also revealed that government should make public enlightenment on health implication of improper automotive waste disposal. This is in conformity with opinion of Warlito and Charlie (2015) who advocated that to avoid exposure to risk from automotive waste requires stringent management practices with adherence to safety standards in handling automotive waste particularly liquid waste. This shows that there is need to enlighten the automotive air conditioning systems especially automotive AC service technicians on the human and environmental health implications of indiscriminate disposal of automotive air conditioning waste.

6. Conclusion

The study determines the automotive air conditioning system maintenance practices embraced by service technicians in Niger State, Nigeria. The findings of the study revealed that the services technicians accepted that inhalation of concentration refrigerant vapour is dangerous and can be fatal to human health and environment. The improper handling and recycling of refrigerant increase Ultraviolet (UV) radiation in ozone layer. A diminished ozone layer allows more radiation to reach the Earth's surface. For people, overexposure to UV rays can lead to skin cancer, skin irritation, cataracts, and weakened immune systems. Increased UV radiation can also lead to reduced crop yield, disruptions in the marine food chain, and other harmful effects which affected the general environment. It was further concluded that ways of improving automotive air conditioning system maintenance practices such as the work area should be ventilated when dispersing vapour, fan or blower should be used in confine area for the dispersion of vapour, Strengthen existing environmental guidelines and standards and develop new ones where necessary in order to counter the increasing level of emissions, automotive refrigerants should not be vent into the air, to mention but a few required by automotive air conditioning service technicians to reduces the effect of refrigerants in the society. Therefore, this study has implication for government, regulatory bodies and Nigeria Automobile Technicians Association for inclusion of these identified automotive air conditioning system maintenance practices required by service technicians which no doubt will assist automotive air condition service technicians during

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maintenance practices with a view to undertake the full safety, collection, disposal, recycling practices of automotive air conditioning systems in the automotive world of work.

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