Journal of Civil & Environmental Engineering

Nwachukwu et al., J Civil Environ Eng 2014, 4:1
DOI: 10.4172/2165-784X.1000136

Research Article Open Access

Concept and Design of Environmentally Friendly Automobile Mechanic Village

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Abstract

Global population increase has caused increased demand in automobile use and the shipment of used automobiles (Second hand) from the industrialized to the developing regions of the world. As a result, many developing countries now opt for auto mechanic village as against the citywide auto mechanic workshop practice because of the numerous advantages. The very poor standard and unsustainable setting of these mechanic villages cause environmental degradation leading to global change. This paper presents a total of 24 features and criteria that enabled AutoCAD design of an environmentally friendly mechanic village. Environmentally friendly mechanic village will improve environmental quality across developing countries of the world this century.

Keywords: Automobile repair; Waste and pollution; Global change; Sustainable engineering

Introduction

A mechanic village represents several acres of land mapped out for automobile mechanics, where automobile owners must go for repairs and services to their motor vehicles. In some parts of Nigeria and many other developing countries, mechanic village (MV) is adopted against the city-wide automobile workshop practice. It is found that citywide auto workshop practice in these countries causes wider environmental pollution. The increasing world population and technological growth (Figure 1a) has continuously increased the use of automobile worldwide (Figure 1b), increasing the use of mechanic villages and global change.

World population was about 2.5 billion in 1950, rose to 6 billion in 2000, while World automobile was about 60 million in 1950 and rose to 700 m in 2000. According to Sousanis [1], which looked at government-reported registrations and historical vehicle-population trends, global registrations jumped from 980 million units in 2009 to 1.015 billion in 2010. The 3.6% rise in vehicles in 2010 was the largest percentage increase since 2000, while the 35.6 million year-to-year unit increase was the second-biggest gain in overall volume ever. The overall vehicle population growth since 2010 has seen China pushing ahead of Japan as the world second largest after United States. The trend has also shown tremendous increase in India vehicle registration, followed by Brazil. The registered figures may double before the end of the first quarter of this century, and similarly increasing the number of mechanic villages.

Mechanic village concept has been described as a twenty first century strategy to improve urban environmental quality in developing countries [2]. While holding on this, Nwachukwu et al. [3], Udebuani et al. [4], and Iwegbue [5] reported that these mechanic villages are poorly developed with no waste management plans. They described the soils as having severe to excessive heavy metal pollution, causing ecological and public health hazards. Nwachukwu et al. [6] found that there is no enforcement of any rule guiding automobile workshops and mechanic practice in the villages. They found the need for mechanic villages to be environmentally friendly. If automobile repair works in cities are confined to well planned and built mechanic villages; with collection and recycling of spent oil, and proper disposal of spent electrolyte, environmental quality will improve. This will reduce soil pollution, bioavailability of toxic heavy metal and poor nutrients availability to crops and vegetables within and around mechanic villages. Heavy metals such as Cadmium, Chromium, Copper, Lead and Nickel are poisonous even at less concentration within an environmental setting.

Activities of Mechanics and their Environmental Implications

It became very necessary to investigate the various activities that go on in mechanic villages, assess their environmental implications to support the design criteria. Table 1 is a breakdown of the various activities of mechanics and other allied works and services that are not environmentally friendly. These activities are duly integrated in the design process.

Background and Justification

Environmentally friendly mechanic village will serve as a base for the transfer of emission testing technology in developing countries, and provide emission testing services to motorists. This will make the enforcement and supervision of automobile emission testing possible in many developing countries, thereby providing the bases for developing countries to integrate climate change responses. It provides temporary storage for the final end of life vehicles. Waste automobiles moved from developed to developing nations at their primary end of life may have temporary storage in mechanic villages at their final end of life following lack of recycling facilities. Have suitable storm water best management practice (MV storm water BMP). This will allow the removal of metal contaminants in the MV storm water, thereby preventing such contaminants from entering the urban waterway, and reducing soil pollution in the MVs [6]. There may be need for extended producer responsibility for used automobile oil. This will end the ugly habit of spilling waste oil on the ground and reduce soil pollution. Lindquist [7] recommended EPR for materials that are recyclable and continuously marketable. Used motor oil is recyclable and also marketable, and the administrative, the economic and the informative tools are affordable and available at this time.

Provision of toilet facilities by government owners of the MVs,

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Received December 09, 2013; **Accepted** January 15, 2014; **Published** January 23, 2014

Citation: Nwachukwu MA, Umunna NA, Ntesat B, Umunna CP (2014) Concept and Design of Environmentally Friendly Automobile Mechanic Village. J Civil Environ Eng 4: 136. doi:10.4172/2165-784X.1000136

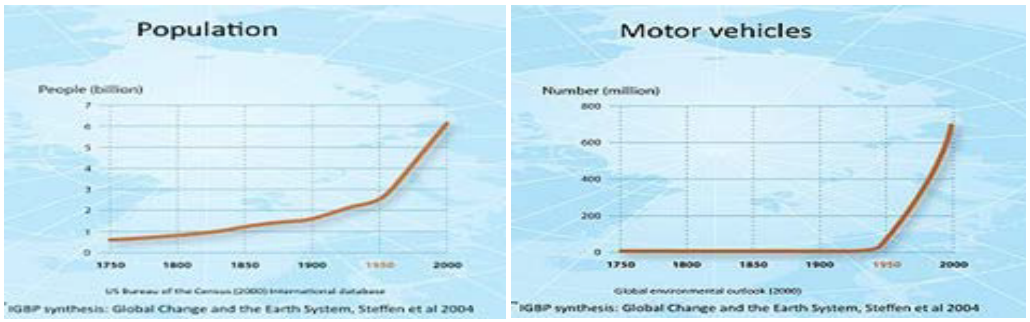

Figure 1: (a) Rapid global population growth (b) Rapid increase in global automobile needs.

S. No.	Activities	Environmental impacts
1	Servicing of vehicles; change oil.	Spill spent engine oil on the ground.
2	Repair of transmission systems.	Spill spent transmission oil on the ground.
3	Repair of fuel tanks.	Spill petrol and diesel on bare ground.
4	Repair or charging of batteries.	Spill used electrolyte on the ground, discard battery casing, and lead plates on bare ground.
5	Repair of braking systems.	Spilling of brake fluid on bare ground.
6	Repair of clutch systems.	Spilling of hydraulic fluid on the ground.
7	Overhauling of vehicle engines.	Discharge used oil, metal particles on ground.
8	Panel beating of vehicle bodies Scraping of old body coats.	Metal bits, metallic coats and dusts on ground.
9	Grinding, threading, wiring etc.	Metal bits are filed onto bare ground
10	Greasing and oiling of parts.	Waste wires, metals and solders are dropped.
11	Welding, soldering vehicle parts.	Grease and oils spill on the ground.
12	Spray painting of vehicle bodies'	Litter carbide, solder, and electrode on ground.
13	Wash potty fill of vehicle body.	Air pollution, pills paints on the ground.
14	Rainfall; Runoff, Storm water	Washery on ground, waste filler in dumpsite.
15	Washing of vehicles and parts.	Roof dirt, Corrosion, Trace metals; Pollutants
16	Human waste	Petrol, Kerosene, Detergent on the ground. Deposited to the ground, no toilet facilities

Table 1: Activities of mechanics and their environmental implications.

which may be supported by the mechanics directly or indirectly will reduce incidents of high coliform counts in shallow wells around MVs. Nwachukwu et al. [8] observed that about 60% of shallow wells within 500 m in the vicinity of Orji and Nekede mechanic villages in the Imo River basin have between 40–70 CF/100 ml of coliform, exceeding the 10 CF/100 ml of water allowable by the world health organization. Be isolated from residential areas in a 50 to 100 year development plan, with farming or vegetable gardens not allowed within and at least 350 m to the MV. Not sited at relatively high elevated areas or at slope up to 10% to reduce transport distance of contaminants. Not sited in areas with shallow water table (water table <45 m in the basin). This will prevent easy transport of pollutants to groundwater and shallow water wells. Have tarred roads and drainage linked to storm water BMPs, as well as concrete floor workshops, to reduce infiltration of contaminants to soil. Have groundwater monitoring wells. This will enable regular study of groundwater chemistry in the vicinity of mechanic villages to prevent dynamic exposure of citizens to water of poor quality. Be provided with health center and recreational facilities, for the occupational health, and mental and physical wellbeing of mechanics. Have continued education program facility for mechanics, to improve awareness of occupational waste management and environmental health and safety in mechanic villages.

Environmentally friendly mechanic villages will stop the neglect of automobile wastes in developing countries, thus strengthening the ability of developing countries to integrate climate change responses. Presently, the worldwide motor vehicle greenhouse gas carbon dioxide emission is said to be over 900 million metric tons each year, predominantly from developed countries according to the World Resources Institute. "These emissions account for more than 15 percent of global fossil fuel CO_2 releases." This obviously has devastating consequences on the environment. Of this volume, the United States that has five percent of the world's population and 30 percent of the world's automobiles contributes 45 percent according to a 2006 report of the advocacy group environmental defense. This quantity may double before the end of the first quarter of this century due to the ever increasing demands of used vehicles by developing countries, and the matching supplies of old fossil fuel guzzling vehicles by the industrialized nations. As the industrialized nations transit to hybrid green electric cars, the need for environmentally friendly automobile mechanic village in developing countries becomes more compelling. To this effect therefore, automobile waste management including final end of life vehicles in developing countries stand as a major global environmental issue of this century.

Lack of storm water treatment facilities in the mechanic villages indicates poor environmental awareness, because infiltration and detention basins are relatively cheap to build and do not involve complex hydrological designs. Galli [9], Hidding [10], Pitt and Clark [11], Gobel et al. [12], Obropta and Kados [9-13], and others have discussed the use of storm water management facilities to improve urban environmental quality. Local phyto-remediation plants will be planted in the central basin to remove the toxic heavy metal contaminants.

Gilbert and Alberto [14] and Remon et al. [15] and others have discussed the principles of phyto-remediation for an effective site restoration. According to Remon et al. [15], indigenous plants species predominant in an area is usually most preferred. This is because indigenous species can easily adapt to relocations and cope with local conditions in a phyto-restoration program. Fakayode and Onianwa [16] obtained strong correlation between heavy metal

concentration in soil and in local guinea grass (Panicum maximum) around Ikeja industrial estate Nigeria. Their result shows significant correlation with respect to Cd (0.83), Mn (0.94), Ni (0.90), and Pb (0.73). This result suggests that Guinea grass could be used for phyto-remediation in mechanic villages.

Another essential component of the waste management plan for environmentally friendly mechanic village is the installation of observation wells near the mechanic villages. Shallow wells (≤ 70 m deep) shall be placed near mechanic villages suspected to be at risk of pollution due to poor waste management. Such wells must be continuously monitored by analyzing the water. Observation wells may be installed ≥ 500 m away from another in a mechanic village, in the direction of drainage. The selected distance of each observation well from its respective mechanic village will depend on the proximity of domestic water wells and human residence.

Methodology and Design Criteria

In this study, a number of Mechanic villages in Nigeria have been visited in order to design a model mechanic village that will be environmentally friendly and stand the test of the 21st century. The field study confirms that the mechanic villages are poorly developed. They are rather brown fields, and obvious source of environmental degradation. Waste management is not at all remembered or considered as an issue, which implies that all waste generated in the mechanic villages are continuously disposed on the ground. Notwithstanding, storm water management is never practiced. There is no environmental regulation guiding the activities of the mechanics neither is there any regulatory agency enforcing any rule. The mechanics are not properly trained, and neither conscious of any regulatory requirement. The workshop structures are predominantly make-shift and ill equipped. Safety standards are low to zero, and quality of work or auto maintenance is poor. The roads and streets are not built, and drainages not provided. Majority of the mechanic villages visited are wrongly sited; often within residential areas and at relatively high elevation areas.

Field investigation of the present state of mechanic villages is recorded in photographs. Auto card was used in the design, making the drawings easy with enough details. Details of the village are contained in the layout design divided into four zones, which describes a mechanic village as a community. Twenty four design features were considered in order to achieve the aim and objectives of an environmentally friendly mechanic village.

Interview with Mechanics

Mechanics interviewed during the field study lamented the poor environmental state of the mechanic villages affecting their health. They informed that on average, they spend twelve hours in the mechanic village Monday through Saturday, while many of their apprentices live in the workshops. They continued that most of their apprentices are on their own, no guardian, no assistance from government or organization. Because of the poor hazardous environment, apprentices are no longer forth coming. Young school leavers and school drop-outs who would have considered automobile repair trade now prefer commercial motor cycle riding obtainable at hire purchase. Our members include mechanics, technicians, artisans, apprentices and other support workers like spare parts dealers and restaurants operators etc. Many of our members are not as educated. Majority are primary and secondary school drop-outs. They are ignorant of environmental health requirements and proper automobile waste management system. We are in search of daily bread but found ourselves in hazardous neglected mechanic villages. We are not happy with the ugly situation but look up to God for rescue they concluded.

Field Assessment of Mechanic Village Infrastructure

Important field observations were captured in photographs

Figure 2: Picture frame view of selected mechanic villages.

representing the physical appearance of mechanic villages (Figure 2). Each photograph in the frame is of a different mechanic village in Nigeria. Greater of the mechanic village activities go on in the open air and on natural ground surface. The entire area is highly congested with unserviceable vehicles and vehicles undergoing repairs.

The earth roads are in deplorable condition contains stagnant pools of water, almost impassable in rainy seasons. Field Records of the present structural situation at selected mechanic villages show evidence of poor development as contained in the photo frame (Figure 2). The environment is hostile to the mechanics and other allied workers including families dwelling within and around the mechanic villages. Most of the mechanic villages lack electricity, water supply, clinic and recreational facilities. There is virtually no engineering input in the overall development, making the environment not conducive for human operation 13 hours per day, 7 days per week.

Project Designs

The concept and design of environmentally friendly mechanic village is hereby presented in Auto Cad with Figure 3 representing the conceptual plan of a medium size mechanic village accommodating 300 - 600 workshops. This size of mechanic village will provide work space for 1000-2000 auto repair workers with similar number of apprentices. The village will also accommodate several allied workers and associate business. In the master plan are four distinguished zones numbered 1 to 4. Zone 1 (Figure 4) is for Toyota, Honda, Hyundai and KIA. This zone has a free area where toilet, bank, power station, police station, gas station, storm water treatment facility and used oil and acid storage tanks are located. This zone deserves to be at most lower elevation within the mechanic village, so that storm water collection and drainage could be supported by natural slope. There is provision for emission testing workshop and a monitoring well which must be located in the direction of drainage. Open spaces and freeways exist in this zone.

Zone 2 (Figure 5) is divided into four quadrants allocated to Volkswagen, Mercedes and Volvo, BMW and Ford, and Nissan. Space is reserved for restaurants, toilets, sorted wastes and used acid and oil

Figure 3: Conceptual plan of a medium size environmentally friendly mechanic village with four zones.

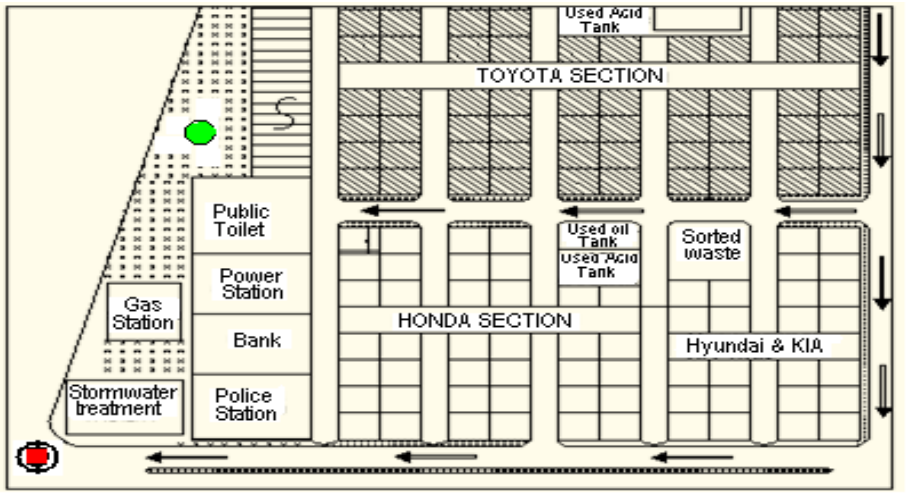

Figure 4: Layout of zone one.

storage tanks. There is provision for emission testing workshop and a monitoring well which must be located in the direction of drainage. Open spaces and freeways all exist in the zone. Zone 3 (Figure 6) is a mixed zone with abundant free way. The zone accommodates a play ground, meeting hall, public water supply scheme, restaurants, health center, central park and a fire service station. Others are: car wash, leather work section, auto electrical section, spray painting section and used acid storage facility. Other major activities located in this section are auto body works, used oil recycling business, junk yard where old parts dismantling and sales take place with storm water treatment. Emission testing workshop and a monitoring well are also provided, with the storm water treatment and monitoring well following the direction of drainage in line with zone 1.

Zone 4 (Figure 7) is the fourth quadrant in the conceptual plan and the most elaborate. This zone accommodates spare parts shops, the truck and bus sections, as well as sorted waste, storm water treatment and toilet facilities. Emission testing facility and a monitoring well are not left out in this zone. Figure 8 is showing a front sectional view of the workshops, with free way in between the workshop sections. Top of the workshops is concrete deck lined with treated soil to provide a green roof suitable for vegetable garden. Figure 9 is also showing a front view of body work/spray painting workshops equipped with gas control chambers to reduce air pollution in mechanic villages.

Explanation and discussion of design

Table 2 comprises a detailed discussion and explanation of the design features and criteria. These features and criteria are conservatively articulated to project the concept of environmentally friendly mechanic village. These design features and criteria are grouped under headings:

- Standardization features and criteria
- Structural features and criteria

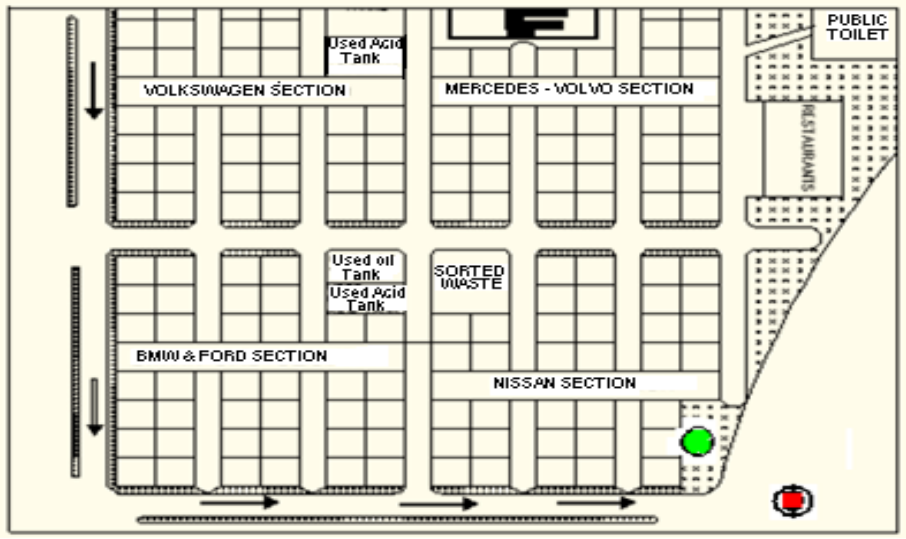

Figure 5: Layout of zone 2.

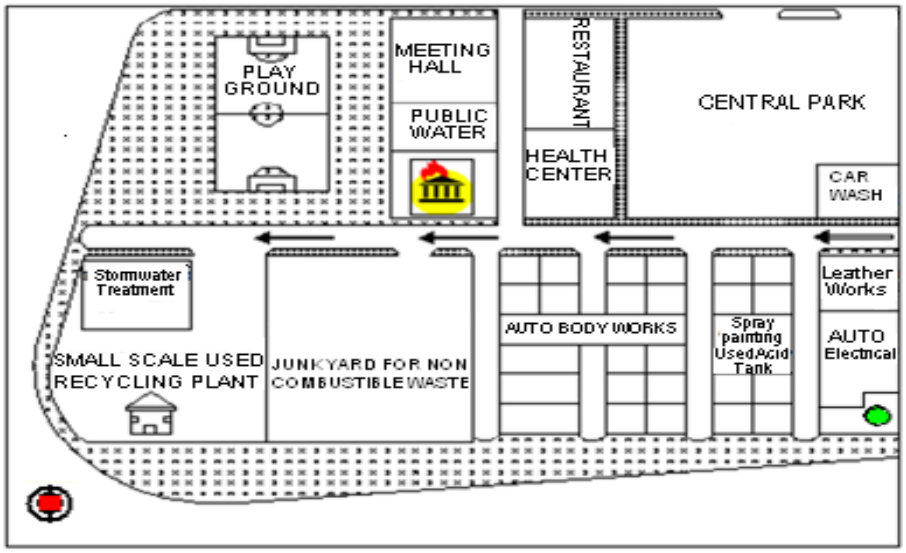

Figure 6: layout of zone 3.

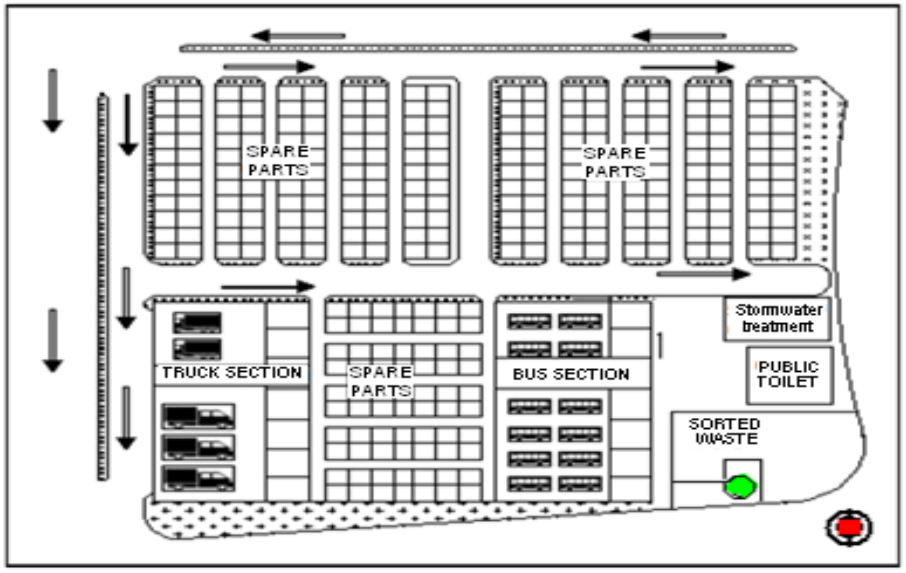

Figure 7: Layout of zone 4.

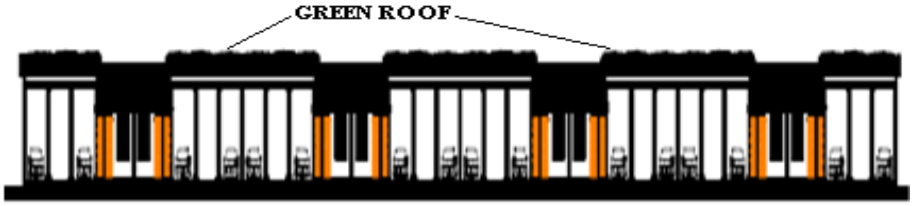

Figure 8: Sectional view of the mechanic village workshop.

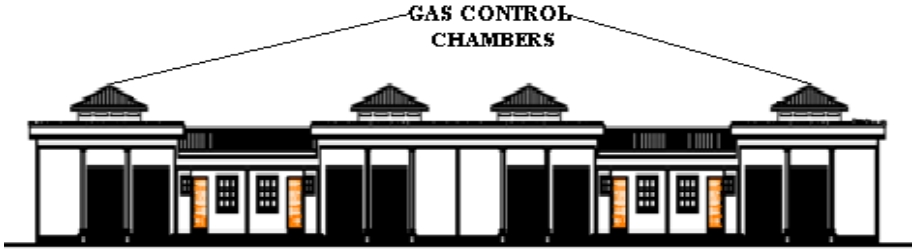

Figure 9: Body work spray painting workshops equipped with gas control chambers.

- Green facilities and criteria
- Support services and criteria

Conclusions

Environmentally friendly mechanic village is a 21st century strategy to improve global environmental quality. The concept appear consistent with the United Nations framework convention on climate change; control of harmful substances and hazardous waste, as well as sustainable development. The concept will rather create an enabling environment for better investments that would attract highly qualified and educated individuals into the business of automobile maintenance. This will create more employment and will endeavor in poverty alleviation as mechanic villages may be described as a training center reachable to the ordinary citizen. The less privileged, which have no support for school and the school drop-outs have position in MVs. It is anticipated that environmentally friendly mechanic village concept may be supported by the United Nations Environmental Program, World Bank, United Nations Development Program, United Nations Industrial Development Organization, and the African Development Bank, etc. Models of MVs may be established in developing countries by governments, the United Nations and NGOs, using the design presented here as a guide. Modifications of the conceptual plan is welcome for design and development processes, but the major features of pollution control should be included to upgrade any existing mechanic villages.

S. No.	Design Features	Specific criteria
Standardization		
1	Size of mechanic village	Small: < 100 acres; Medium: 100-200 acres Large: > 200 acres; based on number of workshops and available land.
2	Criteria for sitting a mechanical village	Elevation; Water table; urban development plan (50-100 years); Accessibility; Population
3	Workshops and Environment standards	As approved by government regulation, and duly enforced by the appropriate agency.
4	Personnel per workshop applicable to all sections	Number of personnel varies from workshop to workshop. This is a function of specialization, expertise, credibility and overall performance.
Structures		
5	Workshop layout and design	Workshops are built in zones with access roads according to different operational activities and specialties. Spare parts dealers and other allied services are properly accommodated in the design.
6	Storm water best management practice	All surface runoff must be directed to treatment facility (storm water BMPs) before it joins the urban waterway. Choice of BMPs, e.g. infiltration or detention basins go with subsurface geology.
7	Accessible road network	Good tarred road network must exist with properly covered concrete drainage.
8	Junk yard	Segregated waste dump area: Junk vehicles; Scrap metals; Auto Plastics for temporary storage.
Green Facilities		
9	Used oil storage	Storage facility per workshop specially designed and supplied by government agency. Stored oil regularly retrieved for recycling or taken care of through extended producer responsibility (EPR). Reduce soil and water pollution.
10	Used electrolyte storage	Storage facility in every auto-electrician workshop. Proper disposal of used electrolyte a condition. Reduce soil and water acidity.
11	Fume and gas collection	Gas collector on top all sprays painting workshops. Reduce air pollution.
12	Green Roof	All workshop buildings concrete tops overlain with good soil for planting food crops and vegetables. Improve air quality.
13	Emission testing facility	Provided by government under regulation to improve air quality.
14	Pollution monitoring wells	A number of observation wells at predetermined locations to monitor groundwater quality.
Support Services		
15	Government owned Fire station	Service truck; Functional water well must be available.
16	Restaurants	Private low, Middle and high class restaurants for native and continental foods will function in MVs.
17	Conveniences	Toilet and shower in every workshop
18	Car wash	One or more, according to size of village
19	Public water supply	Two standard boreholes fully reticulated
20	Car park	General car park and car hire services
21	Transformer station	The MV shall exclusively have its own transformer of high capacity, to enable constant and regulated power supply.
22	Bank	The village union shall allow a bank of their choice to serve them and their customers.
23	Gas station	One or two gas stations are required in a mechanic village to facilitate repairs and run automobiles.
24	Police post	A police post is required to keep law and order.

Table 2: Design features and criteria.

Acknowledgements

The authors remain very grateful to GEOPROBE International Consultants Limited Nigeria for design instrumentation and logistics support that enabled this research. Special thanks go to all persons who helped in the field assessment photographs and processing.

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