

**CONTRIBUTION OF ROAD TRANSPORTATION  
TO ENVIRONMENTAL DEGRADATION IN  
NIGERIA'S URBAN CITIES**

By

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## 1.0 PREAMBLE

Development projects generally cause changes to the environment. These changes (impacts) could be positive where incremental improvements in the general environmental parameters are observed or may cause environmental impairments (negative impacts). However, such developments need not cause major environmental damage if the proper measures and analysis are adopted in the life of the project.

## 2.0 ENVIRONMENTAL CONSIDERATIONS FOR DEVELOPMENT PROJECTS IN URBAN AREAS

Cities play a key role in the development process. They are, in general, productive places that make more than a proportionate contribution to national economic growth. However, the very process of urban growth often brings with it deterioration in surrounding environmental conditions. As a locus for population growth, commercial and industrial activity, cities concentrate energy and resource use and waste generation to the point that both man-made and natural systems are overloaded and the capacities to manage these systems are overwhelmed. This situation is exacerbated with rapid urban population growth. The resulting environmental damages or costs threaten the continued productivity of cities and the health and quality of life of its citizens. Cities have become major “environmental hot spots” that urgently require special attention in regional and in all environmental planning and management at the metropolitan regional scale.

Urban systems and services (e.g., water supply, sanitation, **public transport and roads**) are increasingly congested due to population, commercial and industrial growth coupled with poor urban management. Natural resources (water, air, forests, minerals, land) vital to the cities’ economic development and to future generations are lost or misused through inappropriate urban policies. The radius

of impact of cities on resources lying far beyond their boundaries is steadily increasing. Furthermore, urban areas are inundated in their own wastes and choked on their own emissions as a result of inadequate pollution control and waste management policies and practices.

### **3.0 ROADS ENVIRONMENTAL PROTECTION AND MANAGEMENT**

In recent years environmental protection has become a central management theme for many activities in all sectors. The degree of commitment to environmental management depends upon the interaction of the sector with the environment, the nature of the activities and the environmental impact of such activities.

- Environmental protection recognizes that our presence, either as individuals or as industrial units, inevitably impacts on the environment and often does so in a detrimental way. Consequently action is necessary to protect aspects of the environment that have particular significance, intrinsic value or legal protection; and
- Environmental management acknowledges that we damage the environment by our actions but proving we manage or control the damage within tolerable limits then it is acceptable to proceed.

The two concepts of protection and management are not, and should never be, mutually exclusive. An important concept is that of sustainability, which using the Brundtland definition means “the ability to meet the needs of current generations without compromising the needs of future generations”.

Over the years, the development of road networks across the world has undoubtedly contributed significantly to the changing of the landscape. Clearly those involved in all aspects of the design and construction of roads will be very aware of the, often emotive, issues that surround this highly visible intrusion into the natural environment. In recent years there have been many high profile and protracted protests in the UK and the US over the construction of new roads,

where environmental protection has been the central theme. Conversely older roads, giving access for people to enjoy their environment have become an attractive and valued part of the natural environment. Hence protection and maintenance of the roads environment extends beyond the natural to include the built environment. Ironically engineers may find they have to protect a man-made structure that, at some point in its history, had been the source of environmental damage (for example, Roman roads, listed buildings, or ancient burial sites).

Central to any functional urban settlement is the level and extent of its transportation network. Road, rail and water systems constitute the modes of transport that have been fully exploited by major urban cities around the globe to facilitate the complete integration of the various segments of their economy thus stimulating development. Since these systems are not isolated, interaction between them and the environment often lead to not too beneficial consequences. In Nigeria, the most developed of these systems is road transportation with the roads mainly prominent in the various state capitals and inter-state highways.

Projects limited to road rehabilitation, maintenance, minor construction, as well as to traffic management and regulation **unlike new road construction**, generally involve lesser environmental concerns. The roads are often constructed with no provision whatsoever to address problems such as the runoff quality vehicle emissions and other probable consequences of the road users activities. Thus it is not unusual to find highways of mainly “flushed shoulder” passing through residential hubs, industrial estates and farmlands and since roads and highway surfaces are impervious, they serve as temporary sinks for various types of pollutants which are washed off during rainfall as runoff them to the proximate environment.

Pollution from non-point sources such as highway runoff has continued to be a major source of concern for environmental regulatory bodies and other stakeholders the world over as they contribute to the pollutant load of the

receiving environment, in most cases the water bodies and farmlands. This results to a gradual degradation of the receiving water quality and an eventual impairment of the beneficial uses of such receiving environment. The Nigerian situation is further exacerbated by the reality of increasing large-scale importation of old/fairly used vehicles for use on the Nigerian highways. An Urban centre such as Lagos has a wide network of roads which mostly bridges it numerous canals and the Lagos lagoon. Thus the need to identify, quantify and mitigate potential pollutants as a result of the transportation activities on these roads and highways is most necessary.

Laws and regulations against environmental degradation from activities in the transport do exist. With special reference to this Sector under consideration, the FME, H & UD LASEPA etc have laws and guidelines that mandates effluent limitations standards and adequate monitoring systems for ensuring that all Transportation Projects are environmentally-friendly. Apart from the Federal guidelines, similar standards have been enacted by the LASEPA. Some of the limits and standards are given in **Tables 1-4**. (See Appendix)

### **3.0 ROADS, THE ENVIRONMENT AND THE NEED FOR ENVIRONMENTAL DUE DILIGENCE**

There is a growing awareness that road development has major environmental impacts. Some of the major environmental impacts of road projects include damage to sensitive ecosystems, loss of productive agricultural lands, resettlement of large numbers of people, permanent disruption of local economic activities, demographic change, accelerated urbanization, and introduction of disease.

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A wide range of pollutants have been shown to be present in highway runoff with about 75% (by dry weight) of these pollutants derived directly or indirectly from vehicles, road surface degradation, atmospheric sources and road maintenance. Heavy metals such as Copper, Cadmium, Chromium, Lead and Zinc among others are constantly being studied and monitored in highway runoffs because of their probable mobilization to useable water systems such as the beaches and underground water, where at elevated concentration levels could cause public health risks. As these heavy metals and other pollutants are continuously mobilized to such water bodies and exposed land mass, they ultimately lead to soil and water pollution. Aside the runoff, roadside soil and atmosphere also accumulate pollutants from roads and highways which could be transported over wide area depending on the local climatic condition of the area.

### **3.1 Classification of Pollutants due to Transport Activities in Urban Cities**

The main classes of pollutants in the highway environment include:

- i. Metals: These have been widely studied due to their deleterious effect even when present in trace amount. Metals of interest in the highway environment are aluminium (Al), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mg), nickel (Ni) and zinc (Zn). They are mostly from vehicular body part and tyre wears. Metals

used in catalytic converters are also being such as platinum (Pt), palladium (Pd) and rhodium (Rh) are also being studied.

- ii. Hydrocarbons: sources of this class of pollutant are petrochemical products used in road construction such as bitumen, the more volatile products used fuels e.g. petrol and fuel additives and the less volatile ones like lubricants used during vehicles servicing.
- iii. Solids: These collect on road surfaces and held within the pores found on the road. They serve as point of attachment for different chemical pollutants be it organic or inorganic. The sizes of the solids could be used to determine the nature, level and runoff treatment strategy to be used on a particular road.
- iv. Inorganic salts, herbicides and bacteria: This class is made up of the nitrates, phosphates, and chlorides especially from coastal roads. The nutrients eventually contribute to the eutrophic nature of the receiving water body and chlorides aids the mobilisation of metals from the road surfaces due to its corrosion ability. Herbicides is mainly due to its use in the control of weeds on highway reservation and embankments. Bacteria presence on roads and highways is also due to human activities like roadside defecation waste dumping.
- v. Gaseous Emissions: This is mainly due to vehicles with inefficient or faulty engines which spurn out smoky and particulate rich exhaust. This class of highway pollution source is very common in Nigeria's urban cities. It serves as the main source of CO, CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>2</sub> in the highway environment.

### **3.2 Factors Contributing to Levels of Pollution in the Transportation Sector**

The following factors have been identified by various researches as the main contributors to the levels of pollutant from the roads and highways

- i. Traffic characteristics (volume, speed, braking)
- ii. Climatic conditions (intensity, wind, temperature)
- iii. Maintenance policies (sweeping, mowing, repair, vegetation control)
- iv. Surrounding land use (residential, commercial, industrial, rural)
- v. Percent pervious and impervious areas
- vi. Age and condition of vehicles anti-litter law and regulations covering vehicle emissions
- vii. Vegetation types and highway right of way
- viii. Accidental spills

Vehicles serve as a direct and an indirect source of pollutants on the highways through normal operation and wear and via the deposition of solid materials picked up from the inner roads onto the highway surfaces respectively. Consequently, increased traffic volume tends to lead to increase in the amount of pollutants around the highway environment. Thus busy spots on the highway have been observed to be characterized by poor runoff qualities; pollutant enriched roadside soil and obnoxious atmosphere.

**Table 1: Impacts of highway maintenance/Repair activities**

Highway Maintenance activity	Air Quality	Water course	Landscape	Built Environment	Ecology	Energy	Noise
Vehicle	•				•	•	•
Vehicle maintenance	•					•	
Machinery operating	•					•	•
Cable laying		•	•	•	•		
Drainage			•	•	•		
Pavement repair			•	•			
Hedge/tree trimming			•		•		
Weed control		•	•		•		
Verge maintenance			•		•		
Painting street							
Furniture				•			
White lining	•			•		•	•
Transport, using and storing							
Substances	•			•	•		
Winter service		•	•	•	•		
Street lighting			•	•	•	•	

Example only: There may be other activities to be added or other effects to be considered.

*Source: Institution of Highways & Transportation, UK, 2001*

#### **4.0 IMPACTS FROM MAINTENANCE AND REHABILITATION (M & R) PROJECTS**

In many countries, an increasing share of land transportation budgets is being allocated to rehabilitation and maintenance of existing roads, rather than going toward new road construction. This section summarizes some of the environmental issues which may accompany these projects and broadly, how they can be mitigated.

##### **4.1 Defining maintenance and rehabilitation**

Routing maintenance refers to activities such as grading, grass cutting, drain clearing, pot-hole patching, and shoulder repairs, which are performed at least weekly, if not more frequently.

Periodic maintenance activities are typically scheduled over periods of several years and include resurfacing and bridge repairs. Other maintenance activities considered to be periodic include seasonal maintenance, such as snow clearing and flood repairs, emergency maintenance to reinstate roads after major failures, and the regular upkeep of safety features and road signs.

Rehabilitation involves more substantial intervention to strengthen a road, repair structural defects, and restore the road to its initial condition, often after it has deteriorated to an unmaintainable state. Rehabilitation sometimes also includes changes or improvements to previous characteristics; for instance, by widening, making small alignment changes, or providing footpaths.

##### **4.2 Impacts of Roads M & R**

As with other road construction activities, road maintenance and rehabilitation works can contribute to soil erosion, disturbance of water flows, chemical pollution, traffic disruption, noise, and other impacts on surrounding communities and natural life (Table 18.3).

Four issues especially relevant to this issue are:

- i) chemical pollution caused by herbicides used for weed control, the application of salt used in winter maintenance, and chemicals used in pavement stripping and resurfacing;
- ii) waste materials from drain clearing, pavement reconstruction, and other activities disfiguring the landscape and finding their way into waterways;
- iii) safety of road workers and other road users, sometimes put at risk by inadequate traffic management and work zone controls; and
- iv) displacement of existing dwellings and business resulting from shoulder improvements and widenings.

Erosions, flooding, road accidents, traffic noise, and deterioration landscape quality are examples of environmental impacts which may be commonly avoided by timely maintenance actions.

Grass and other roadside vegetation provide erosion protection by slowing flow and trapping suspended matter. Too much vegetation can be a safety and fire hazard or a habitat for local wild plants and animals including human miscreants. These can be avoided and enriched through appropriate maintenance action. It needs to be emphasized too that good maintenance work can also generate positive impacts by eliminating or reducing the environmental problems caused by the deterioration of road surfaces, drains, and shoulders, and also cause very pleasant aesthetics.

## **5.0 STUDIES ON EFFECTS OF ROAD TRANSPORTATION ON HIGHWAY RUNOFF, ROADSIDE SOIL AND ATMOSPHERE IN NIGERIA**

We have initiated a novel serial study of the impact of Transportation and Urban Highway runoff on the environment of the large city in Sub-Saharan Africa (and the commercial and industrial capital of Nigeria): Lagos in order to understand the dynamics and extent of contributions of highway runoff on the environmental pollution burden of urban areas in developing countries. The

studies have been embarked upon to characterize and quantify the pollutant in highway runoff, roadside soil and atmospheric depositions from major highways in metropolitan Lagos and other part of Nigeria and their effects on the receiving environment. The studies have characterized for the first time the types and levels of pollutants in the urban highway particularly the heavy metals in sheet flows. Results obtained showed the presence of heavy metals such as zinc, lead, copper, nickel and chromium and other pollutant indicating parameters in these media. (Alo B.I et al 2001, 2006, 2007)

#### Roadside Dust (Alo B. I and Olayinka K. O., 2001)

In a study conducted in Lagos, Ibadan and Benin, Pb was found to be present in road dust of particle sizes ranging from 0-100 $\mu$ m from roads has showed obtainable concentration could be as much as 6000 $\mu$ g/g. National Limit = 1ppm

#### Runoff / Roadside soil on Apapa-Oshodi Expressway, Lagos (Alo B. I., 2006)

The levels of the heavy metals observed for the runoff and soil samples were relatively high at busy spots such as Oshodi and Tin-Can areas of the expressway. A peak concentration of 69.1mg/kg Zn, 157.6mg/kg Pb and 18.1mg/kg Cu was obtained in the roadside soil. The runoff quality was poor with very low dissolved oxygen level, high chemical oxygen demand, high dissolved solids and chlorides contents.

#### Runoff from Ikorodu Road, Lagos (Alo B. I. et al, 2007)

This study was conducted in 2004 on the eight lanes dual carriage busy Ikorodu road. Result obtained showed the presence of Zn, Cu, Pb and Cr Zn being the most prominent with concentration range of 0.076-0.200mg/l. The runoff quality was low with low dissolved oxygen and high biochemical oxygen demand. A receiving stream along the highway around Obanikoro also showed the presence of these metals though their concentrations were lesser due to the dilution of the

stream water. Pb had concentration ranges of 0.003-0.074mg/l and 0-017-0.026mg/l in runoff and stream samples respectively.

Atmospheric Deposit/Runoff/Roadside soil at Oshodi and CMS, Lagos (Alo B. I et al, 2007)

Atmospheric deposits, runoff water and roadside soil from two points on two different highways in Lagos Metropolis showed the presence of Cu, Cd, Cr, Ni, Pb and Zinc. The observed concentrations for the deposits were in the order ; Zn>Cu>Pb>Ni>Cr>Cd. These concentrations correlate with the levels of the metals in the runoff and soil samples and with increase in the degree of human activities observed on the different highways. By implication, one approach that could serve as a control measure towards reducing the levels of observed heavy metals in highway runoff would be through limiting the levels of particulates in the highway environment.

## **6.0 MITIGATION STRATEGIES FOR ROAD TRANSPORTATION IMPACTS**

Since environmental impacts from road development are quite common, Road projects usually call for initial comprehensive environmental assessment studies, carried out by EA professionals (both specialists and generalists) who support the main engineering team as well as continuous monitoring of environmental safeguards and the project's approved EMP. Substantial time and effort is often required to identify potential impacts and options for minimizing them , to consult with various groups who have an interest in the project and to develop and implement mitigation plans. In addition, construction contractor's contract clauses covering work procedures and staff's training need to be prepared, and work processes in relation to roadside communities, flora, and fauna given considerable attention.

In order to conduct EIAs and the Environmental Monitoring successfully, the road agency needs to have a dedicated core staff on Environmental Safeguards who need to understand the processes and procedures and must coordinate with the road planning, engineering design, and construction activities Units of the Agency, and must be empowered with sufficient funds for all necessary steps.

It is essential that such road agency staff be able to

- Recognize potential environmental concerns;
- Know when to call in specialist experts;
- Know how to specify and manage their work; and
- Know how to implement mitigation plans and environmental contract clauses.

New skills may have to be developed to meet the demands of the EIA and Environmental Monitoring processes. This is especially true in the area of consultation with affected residents, interested members of the public, government departments, and other organizations (known collectively as the stakeholders). While road agencies are generally quite responsive to the concerns of these stakeholders on engineering issues, the dialogue on environmental matters often need to be expanded to include a broader range of topics. Agency staff involved in the consultation process must be equipped to address varying institutional and cultural needs and differences.

Perhaps the most important mitigative measure related to road maintenance and rehabilitation projects is to ensure that maintenance measures, the Project EMP and Environmental Safeguards included in the road design, operate effectively. These can be enhanced by

- Protection of the biophysical environment can be assisted by regular drain clearing, upkeep of vegetation on slopes and exposed surfaces, maintenance of flow speed reduction devices in drains, removal of waste materials arising from road works, and avoiding the use of herbicides and other toxic or polluting substances.
- Impacts on the community and social environment can be mitigated through well-designed traffic management plans, the use of quite

equipment, operating during daily periods of high ambient noise and focusing attention on improvements in the quality of signs, guardrails, footpaths, and other features which contribute to safety and local accessibility.

- Environmental “hot-spots” or problem locations, such as easily-eroded sites or notoriously unstable slopes, can be identified during the VEC identification step and during the execution of rehabilitation and maintenance works.
- Experts in roadside vegetation, traffic management, and transportation safety should monitor maintenance activities to ensure that work practices meet environmental objectives. Understanding the functions and techniques of roadside planting, signs, and guardrails is important for their proper functioning.
- Training of road crews in these issues can help them considerably in correctly executing and managing maintenance works.

An environmental management framework must be developed and must include matrices that:

- match activities with the environmental impacts
- match environmental impacts with the legislative requirements and
- identify cause, effect and control

While it is accepted that protecting the environment, as it now exists, has to be an integral part of environmental management there is a need for common-sense practical measures to help apply the concept to the maintenance of highways. Environmental management takes full account of the issues, the relevant pollutants and the trade-offs to be considered when maintaining a balanced environment (see Table 2.0 on **Typical impacts and mitigations from bituminous road use**).

**Table 2.0 TYPICAL IMPACTS AND MITIGATIONS FROM BITUMINOUS ROAD USE** (Source: *Institution of Highways & Transportation, UK, 2001*)

Item	Activity	Effect	Impact	Comments
Aggregate Extraction	Structure maintenance materials require aggregate that is generally quarried locally. This is a non-renewable resource.	Adverse	Moderate	<p>Recycling of old pavement layers is already permitted under the specification. This is at the contractor's option but is not frequently used. Central government may in future decide to introduce an aggregate extraction tax and that would encourage more recycling. If not, a more pro-active approach to increasing the amount of recycling should be considered</p> <p>The proposed NI Waste Management Strategy includes mandatory targets for increased recycling and reduced waste. This will be an additional driver for recycled pavement materials.</p>
Bitumen	Bituminous road making materials. Bitumen is a by-product of the petroleum industry and is therefore a non-renewable resource.	Adverse	Small (in terms of total use of oil products)	<p>The only alternative to bituminous mixture is a concrete pavement. While this would be suitable for major reconstruction schemes experience tends to favour flexible bituminous materials.</p> <p>There may be a small advantage in using asphalt rather than bituminous macadam. Asphalt has a higher bitumen content, lasts longer and does not require bitumen-based surface dressing every seven years. The mitigating effect would be marginal.</p>
Energy	Bituminous and concrete materials require energy for manufacture and	Adverse	Small (in terms of total energy)	<p>The adverse environmental impact is very small in terms of total energy use.</p>

	transport to site.		use)	
Noise	<p>More frequent resurfacing produces smoother surfaces and means fewer potholes and uneven reinstatements; this results in less noise and vibration</p> <p>New types of bituminous pavements are significantly quieter.</p>	Positive	Moderate	<p>A good structural Maintenance Plan will help to produce smoother surface, with less noise which benefits people living or working close to heavily-trafficked roads.</p> <p>Thin Surfacing and Stone Mastic Asphalt are relatively new materials that generate much less traffic noise. Their use may be considered on routes where traffic noise is a problem, subject to good durability and long-term skidding resistance. <i>(Note: An adverse effect of extending the use of these materials is the increased volume of high PSV aggregates being used. A balance will have to be struck).</i></p>
Ride Quality	<p>More frequent resurfacing produces smoother surfaces, fewer potholes and reinstatements; this reduces vehicle operating costs.</p>	Positive	Small	<p>A good Structural Maintenance Plan will help to produce smoother surfaces and consequently lower vehicle operating costs, but the savings will be small in terms of total costs.</p>
Safety	<p>More frequent resurfacing and surface dressing increases skidding resistance which reduces skidding accidents.</p>	Positive	High	<p>A good Structural Maintenance Plan will help to greatly increase skidding resistance. There were circa 21500 accidents involving wet skidding in the UK during 1998. These resulted in 470 fatalities and over 59,000 injuries. The social cost of all accidents in that year was approximately £16,000m. If a structural maintenance plan prevents just 25% of such accidents, the associated annual benefits should cover the increased cost of its implementation.</p>

## 7.0 CONCLUSIONS

Developed countries have active road and highway management authorities whose functions among others is to ensure a balanced transportation sub-sector and a clean environment even within an efficient public transport delivery paradigm. They ensure that road construction and the subsequent activities of road maintenance do not serve as source of pollutants to the environment. Best management practices (BMPs) are put in place along every road and highway to reduce or totally eliminates pollutants from highway runoff. These BMPs include considerations for issues such as land use and comprehensive site planning, landscaping and vegetation management practices, illicit waste dumping control, street sweeping etc.

The LAMATA is blazing an excellent trail in Public Transportation management in Nigeria. This must continue especially as we embark on an integrated transport systems for Nigeria's emerging megacities which must include an integrated mass rapid transit system as an imperative.

As we fashion out comprehensive solutions and policies towards achieving effectiveness and standardization in public transport delivery, Nigeria's urban cities authorities need to mainstream environmental considerations strengthened by our extant environmental laws and regulations. Such policies must include measures to control vehicular emissions, age and state of vehicles and illegal roadside activities, periodic EAs and reviews of environmental performance etc towards reducing the contribution of the road transportation to environmental degradation. In the long term, structural BMPs should be incorporated in new road designs to arrest pollutants in runoff before it discharges into the water bodies. Also, new highways should be directed away from any impact-able resources as well as human habitation and measures put in place to prevent any roadside enterprises from setting up along the highways.

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