Anthropologist, 12(4): 277-287 (2010)
PRINT: ISSN 0972-0073 ONLINE: ISSN 2456-6802
DOI: 10.31901/24566802.2009/12.04.07

An Assessment of the Environmental Impact of Asphalt Production in Nigeria

Momoh L. Rilwani* and Fred E. Agbanure**

**Department of Geography & Regional Planning, Ambrose Alli Univesity, Ekpoma, Edo State, Nigeria*
Telephone: +234 803 953 2352, +234 805 618 0468; E-mail: mlrilwani@yahoo.com
***Delta Direct Labour Agency, Delta State, Nigeria*

KEYWORDS Roads. Hot Mix Asphalt (HMA). Environmental System

ABSTRACT This study assessed the impact of asphalt production on the environment in Nigeria, using the HMA facility of the Delta State Direct Labour Agency located at Agbarha-Otor in Ughelli North Local Government Area, Delta State as a case study. Soil, water and vegetation samples were obtained in a field survey, while interviews and focus group discussions were also held with the stakeholders. Analysis of the laboratory results of field samples taken reveal that the HMA facility has some limited impact on the soil, vegetation and water around it. In particular, the statistical analysis shows that the impact on the Cadmium and Benzene contents in the soil is significant, while the impact on the other pollutant elements considered are not significant. For vegetation and water, the impact on the elements considered is not significant. Analysis of the interviews and discussions held with the stakeholders reveal that the HMA facility has impacted both positively and negatively on the socio-economic activities and health of the host community.

INTRODUCTION

Roads are the most important medium of movement. Thus, good network of roads have been a major demand of most communities. In fact, a good proportion of the annual budgets of developing countries are spent on road construction, while developed nations treat road improvements (maintenance) with high priority.

In Nigeria, the expansion in road network and vehicular fleets make the road transport mode the dominant mode in terms of passenger and goods traffic. For instance, the highway mode accounts for about 96 percent of total domestic passenger traffic in Nigeria, while the rest (water, air, and rail) account for just 4 per cent (Arosanyin 2000).

There are two major types of road pavement in Nigeria. Those finished with asphalt wearing course, are referred to as *flexible pavement* roads, while those finished with a reinforced concrete, are referred to as *rigid pavement* roads. More than 90 percent of all the roads constructed in Nigeria are of the flexible pavement type. A release by the Federal Ministry of Works and Housing, Highways Management Services Division in 1994 showed that of all the 32,097km of Federal Highways, 18,250km are of asphalt concrete wearing course carriage and another 7,877km are made up of asphalt surface dressing, both types being flexible pavement (FMWH 1994). The remaining 5970km are the then yet to be constructed earth roads.

The production of hot asphalt concrete is done at an Asphalt Plant also known as Hot Mix Asphalt (HMA) facility. Hot Mix Asphalt facility is an assembly of mechanical equipment where aggregates (i.e. inert mineral materials such as sand, gravel, crushed stone, slag, rock dust or powder) are blended, heated, dried and mixed with bitumen (asphalt cement). Hot Mix Asphalt facility can be constructed as a permanent plant, a skid-mounted (easily relocated) plant, or a portable plant.

Asphalt plants are numerous in Nigeria. Every major road project has an asphalt plant installed for asphalt production by the construction company. Some construction companies, on the other hand, have their HMA facility centrally located in their area of operation and hence feeds more than one road project with asphalt from the one centrally located plant.

Hot Mix Asphalt facilities are comprised of the same basic environmental pollution sources. These are the dryer, burner-blower, exhaust fan, dust collection system, asphalt cement heating and storage, and reclaimed asphalt paving components. Most of the pollutants emitted from Hot Mix Asphalt facilities are particulates. Sulphur dioxide, carbon monoxide, nitrogen oxides and volatile organic compounds (VOC) are gaseous emissions that are also emitted. Gaseous emissions come from the burner-blower, exhaust fan, asphalt storage, storage silos, heating systems, loading and transportation. Each operation can be a potential source of pollution if controls are not employed.

The impact of development projects (such as road construction and maintenance) on our physical environment and human well-being is attracting serious attention throughout the world (UNCED 1992). However, the impact of Hot Mix Asphalt plants on the physical and socio-economic environment of host communities in Nigeria is yet to be addressed. This research, therefore, focuses on the assessment of the impact of asphalt production on the environment of Agbrha- otor, a rural farming settlement located near Ughelli in Delta State, Nigeria where one of the Hot Mix Asphalt facilities of the Delta State Direct Labour Agency is located. The objective is to assess the impact of asphalt production on the natural environment at Agbarha-otor and environs, with particular reference to the soil quality, vegetation and domestic water supply. The health implications and socio-economic benefits of the Hot Mix Asphalt facility to the host community are also discussed, and recommendations to avert the negative impacts proffered.

Description of the Area of Study

An Asphalt plant located at Agbarha-otor near Ughelli town was chosen for this study. The Delta State Direct Labour Agency runs the plant. Agarha-otor lies roughly on Latitude 5.31°N and Longitude 6.05°E. It is about 6 kilometres from Ughelli, the headquarters of Ughelli North Local Government Area of Delta State, Nigeria.

Recent sediments of the Niger Delta underlie the study area. The soils are alluvial, while the vegetation lies within the Deltaic and Seasonal Swamp Forest region of Nigeria. It has an annual mean rainfall of 350cm and a mean annual temperature of about 27°C. The prevailing winds are the Southwest Monsoon (March to October) that brings rains and the dry (*Harmattan*) Northeast Trade Wind (November to March).

The terrain is very flat and is poorly drained with the result that swamps and ponds are common in the community during the rainy season. These become partially dry and some even dry up during the dry season. The Okpari creek, which is located to the north of the community at a distance of about 200 meters south of the asphalt plant yard, is the only source of surface water supply in the community.

The main occupation of the people of Abgarha-Otor is farming. The asphalt plant is surrounded on all sides by small farm holdings. Cassava is the main food crop planted and rubber is the people's cash crop. Fishing is carried out in the numerous ponds.

Theoretical Overview

A *system* is a structured set of objects and/or attributes which is comprised of a collection of components or variables that show discernable relationships with one another, and operate together as a complex whole based on certain observed pattern (Wilson 1981). The *system* is further understood through the submission of Okafor (1988), who defines the term in the context of interaction, which simply means the process by which two or more objects having mutual action, act on one another.

Environmental system presupposes literally that which surrounds man's act in an interactive manner either within themselves or with men. All parts of the environment work together, giving to and receiving from one another the things necessary for life (Billington 1977). Okafor (1988) grouped the components of the environmental systems into five: Terrain (Mountain, hills and valleys); vegetation, climate (temperature, humidity and precipitation); soils, and artifacts (man-made components).

An understanding of the composition of the earth may assist in the identification of the systems in man's environment, especially with reference to the interactions, which exist within. The earth is considered by Monkhouse (1975) as the life-bearing layer, which lies at or close to the vital interfaces between the earth realms including the gaseous realm (atmosphere), liquid realms (hydrosphere), and the solid mineral realms (lithosphere). Jeje and Adesina (1996) referred to these as the physical components of the earth. Our earth environment can therefore be said to be composed of the atmosphere (gaseous portion), which envelops the earth; the hydrosphere or the world water (liquid portions); the lithosphere or rocky crust of the earth (solid portions); and the biosphere, which contains organic or living matter. Each of these components constitutes a system and there also exist numerous subsystems. Under normal circumstances circu-lation within these systems continues unabated.

The human component of the environment is man and his social, economic and cultural activities, such as settlement, communication routes (road construction) among others. The relationship between man and his environment is a crucial one. Because of the involvement of man also as a system interacting with other systems (environmental systems) to make a whole life system, abnormal cases are often experienced. In other words, the normal circles of environmental systems may either be delayed or disorganised. For instance, man's impact on the atmospheric systems concerns the effects of climatic change, in particular man-induced changes (Ajibade 2000).

The levels and rates of interactions between man and the environment depend on man's needs, modes of meeting the needs, and perhaps the level of his technological developments. Jimoh (2000) identified three phases of these interactions. The first is the Paleolithic era, when man's needs centered mainly on food and shelter. The second phase is the Neolithic era (middle age) during which the environment was capable of offering possibilities (environmental possibilism). The third phase coincides with the modern age and it is characterised by man's desire for various needs for comfort. Man has thus, devised several methods to meet these needs. In this view, there has been a high positive relationship between man and the environment. This has spelt disastrous consequences on the environment due to man's uncaring attitude. Consequently, the emerging environmental problems threaten both man's presence and the future too. For instance, in an attempt to provide roads for movement of persons, goods and services which is an indispensable component of modern society, man inadvertently disturbs the natural system of the environment. Part of this disturbance is associated with the particulate and gaseous emission, which are released into the environment from Hot Mix Asphalt Plants.

Majority of the roads in Nigeria are finished with asphalt concrete derived from Hot Mix Asphalt plants. The emissions from these plants constitute pollutants because they are harmful substances released into the environment (Akinbamijo 2000). Hot Mix Asphalt facilities have two major sources of emissions. These are *ducted sources* and *fugitive sources* (Ciammaichella 2000). Both sources emit particulate materials and gaseous pollutants into the atmosphere. However, ducted emissions constitute the primary source of particulates. These come mainly from the heated aggregate in the rotary drum dryer, and are usually collected and transported by an industrial ventilation system with one or more fans or air movers. They are eventually emitted into the environment through a stack of considerable height from the ground. Fugitive emission on the other hand, consists of a combination of gaseous pollutants and particulates. The major source of emission in batch-mix plants is the collection device, called a fugitive dust or scavenger system. In all asphalt plants, organic vapour (asphalt fumes) and its associated aerosol may also be emitted directly into the atmosphere as process fugitives during truck loading from the asphalt storage tanks or storage silos, and from the truck during transportation to the job site (OSHA 2002). However, a lot more of the asphalt fumes are emitted during discharge of the already mixed asphalt from the truck to the road paving plants on the job site (WSDNR 2001).

The impact of the deposition of such large amount of dust particulates and gaseous pollutants on the environment are enormous, and yet to be given due attention in Nigeria. The multiplier effects and the attendant environmental degradation, pollution and associated hazards, and the disruption of ecological balance, underscore the need to preserve the environment in its original sate, or in a state that can be harnessed for sustainable human development (Ogiehor and Omonfomwan 1998).

METHODOLOGY

This research is essentially a field-based exercise designed to assess the quality of the physical environment of the asphalt plant at Agbarho-Otor in Delta State, Nigeria. Data were gathered from primary sources involving field surveys, during which samples of soil, plants and water were collected. The samples were analysed at the Nigeria Institute for Oil Palm Research (NIFOR) near Benin City, Nigeria. Oral interviews and group discussions were also carried out, with a focus on (i) the inhabitants of the area, (ii) staff of the Hot Mix Asphalt facility and (iii) health workers in the area, to elicit information on the socio-economic and health impact of the facility.

For soil, parameters on which data were collected include Nitrogen Oxide (NO), Sulphur

Dioxide (SO_2), Carbon Monoxide (CO), Volatile Organic Compounds (VOC), Benzene, Formaldehyde, Toulene and Cadmium. This set of parameters constitute the common pollutants from asphalt plants (FEPA 1991) and was used to determine the general level of pollutants in the soil. The soil sampling points were based on 2km by 2km grid system. A total of 14 sampling points were established. From each point soil samples were collected using a soil augur at depths of 0-15 cm, and 15-30cm. Table 1 shows the location of each sample, the distance as well as direction from the asphalt plant. Cells M and N, which are at 9.5 km and 9.0 km respectively from the asphalt plant were deliberately chosen to provide *control samples*. This is because they are located at reasonable distances from the exact location of the asphalt plant.

Table 1: Location of soil sampling points

Sample no.	*Cell of collection*	*Approximate distance from Asphalt plant*	*Approximate direction from Asphalt plant*
1 A&B	A	4.0 km	North-west
2 A&B	B	2.5 km	North
3 A&B	C	1.0 km	North
4 A&B	D	1.0 km	East
5 A&B	E	3.5 km	West
6 A&B	F	0.5 km	South
7 A&B	G	0	-
8 A&B	H	2.0 km	East
9 A&B	I	4.0 km	South-west
10 A&B	J	2.0 km	South
11 A&B	K	2.4 km	South-east
12 A&B	L	4.3 km	South-east
13 A&B	M	9.5 km	South
14 A&B	N	9.0 km	South

Source: Field Survey 2002

Vegetation data extracted were from cassava plants. Parameters on which data were collected include Nitrogen, Phosphorous, Potassium, Calcium, Magnesium, Sodium and Sulphate. These were used to assess the impact of the asphalt plant on vegetation. Three samples (cassava leaves) were collected from different locations around the asphalt plant. The first sample was collected at about 8.5 km south of the plant, the second at the northern boundary of the asphalt plant premises, while the third was taken from a farm located at about 1.5 km from the plant.

For water, data were collected on pH level, Chlorine, Sulphate, Calcium, Magnesium, Sodium, Potassium, Chemical Oxygen Demanded (COD) and Nitrogen contents. These were used to assess the quality of the available water for domestic consumption. Three water samples were collected. The first sample was taken from a borehole situated inside the asphalt plant premises. The second sample was taken from Okpare creek, a significant source of water for domestic activities for the community, which is situated about 260 metres south of the location of the asphalt plant. The third sample comprised rainwater ,was collected at about 1km south of the asphalt plant.

The Pearson Product Moment Correlation Coefficient (T-Test) and Analysis Of Variance (F-Test) were used to ascertain the significance of the correlation and differences between values of parameters tested with distance from the location of the asphalt plant.

RESULTS AND DISCUSSION

The Impact on Soil

The result of the soil pollutant elements test is shown in table 2. To assess the impact of the various pollutant elements from the asphalt plant at Agbarha-otor on the soil of the surrounding area, the result of the pollutant elements analysed for samples A to L were compared with those of M and N (the control samples), consequent upon which a linear relationship between pollutant elements and the distance from the asphalt plant was established. The pollutant elements considered are Carbon monoxide (CO), Nitrogen oxide (NO), Sulhpur dioxide (SO_2), Volatile Organic Compounds (VOC), Benzene, Toluene, Formaldehyde, and Cadmium.

Carbon monoxide content in the soil ranged from a mean value of 1.43 to 3.66g/kg. With a correlation coefficient (r) value of 0.41, t-test value of 1.56, the table value at 5% confidence level is 1.782. This implies that no significant correlation could be established between Co value and distance. Invariably therefore, there is no significant difference between the CO content of the soil samples taken near the HMA plant and those far from it, another way of saying that the Hot Mix Asphalt plant has no significant impact on the CO content of the soils around it. Figure 1 illustrates this relationship.

Nitrogen oxide content of the soil samples ranged from a mean value of 0.087 to 0.179 g/kg. There is also no correlation between the distance from the plant and the amount of Nitrogen Oxide

Table 2: Result of Soil Pollutant Elements Test

S.No.	*Sample No.*	*CO (g/kg)*	*NO (g/kg)*	*SO_2 (g/kg)*	*VOC (mg/kg)*	*Cadmium (mg/kg)*	*Benzene (mg/kg)*	*Toluene (mg/kg)*	*Formaldehyde (mg/kg)*
1	1A	1.730	0.111	0.134	29.00	0.012	0.000	16.400	0.004
2	1B	1.120	0.062	0.537	22.00	0.024	0.000	5.200	0.004
3	2A	3.730	0.199	0.403	46.00	0.030	0.000	6.400	0.004
4	2B	2.990	0.159	0.403	35.00	0.006	0.000	2.400	0.008
5	3A	2.850	0.139	0.134	48.00	0.012	0.400	5.600	0.004
6	3B	0.750	0.045	0.268	29.00	0.018	0.000	5.600	0.040
7	4A	2.680	0.176	1.742	62.00	0.012	0.000	7.600	0.016
8	4B	2.240	0.129	2.145	44.00	0.006	0.000	11.200	0.004
9	5A	2.990	0.154	4.290	43.00	0.012	0.400	11.600	0.040
10	5B	2.010	0.119	8.851	41.00	0.024	0.400	5.600	0.008
11	6A	1.630	0.105	0.134	49.00	0.012	4.000	6.800	0.012
12	6B	1.560	0.094	0.403	35.00	0.012	3.200	10.400	0.004
13	7A	2.750	0.161	0.268	44.00	0.006	3.600	6.000	0.016
14	7B	1.350	0.081	12.200	32.00	0.018	4.000	15.600	0.012
15	8A	2.380	0.146	0.134	55.00	0.048	3.600	9.600	0.004
16	8B	1.350	0.084	0.403	24.00	0.042	0.000	4.800	0.008
17	9A	1.870	0.120	0.403	40.00	0.048	0.000	5.600	0.004
18	9B	1.260	0.075	9.654	29.00	0.018	0.000	4.000	0.016
19	10A	2.470	0.141	0.268	45.00	0.054	0.000	5.600	0.004
20	10B	1.940	0.126	0.268	31.00	0.036	0.000	7.200	0.004
21	11A	2.540	0.154	0.403	39.00	0.024	0.000	7.200	0.008
22	11B	1.940	0.120	0.268	35.00	0.048	0.000	1.200	0.004
23	12A	2.540	0.148	0.805	41.00	0.036	0.000	12.800	0.040
24	12B	1.940	0.118	12.470	31.00	0.018	0.000	8.000	0.024
25	13A	5.530	0.236	0.268	67.00	0.024	0.800	12.800	0.004
26	13B	1.800	0.107	0.268	41.00	0.006	0.400	7.200	0.004
27	14A	2.540	0.146	0.134	40.00	0.024	0.400	8.800	0.004
28	14B	1.730	0.105	0.268	30.00	0.018	0.400	4.800	0.008

Source: Laboratory Analysis 2002

present in the soil. With a correlation coefficient value of 0.31, t-test value of 1.13 and table value of 1.782, it is glaring that no correlation could be established between values of nitrogen oxide in the soils with respect to distance (see Fig. 2). Thus, there is equally no significant difference in the nitrogen oxide content in the samples. It can thus be asserted that the Hot Mix Asphalt plant has no significant impact on the nitrogen oxide content of the soil around it.

Sulphur dioxide content of the soil samples ranged from a mean value of 0.201 to 6.638 mg/kg. With an inverse correlation coefficient value of –0.14, t-test value of –0.49 and table value (at 5% confidence level) of 1.782, it is clear that no significant relationship exist between SO_2 and distance from the plant. It could be however be asserted from Figure 3 that the sample taken at the exact location of the plant and those taken at about 4 to 5 kilometres from the plant apparently

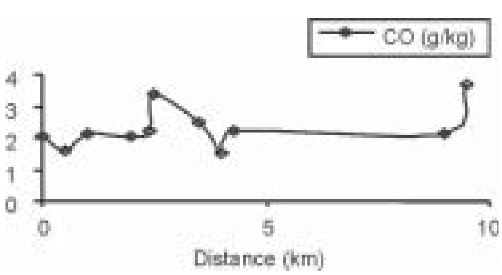

Fig. 1. Relationship between carbon monoxide in the soil and the distance from the plant

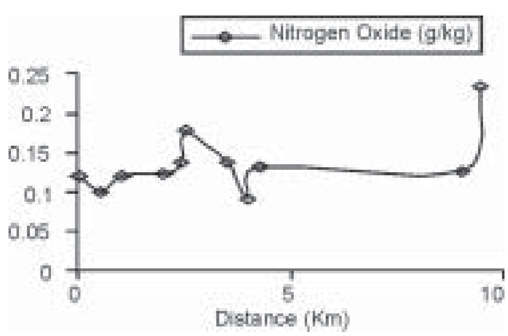

Fig. 2. Relationship between nitrogen oxide in the soil and the distance from the plant

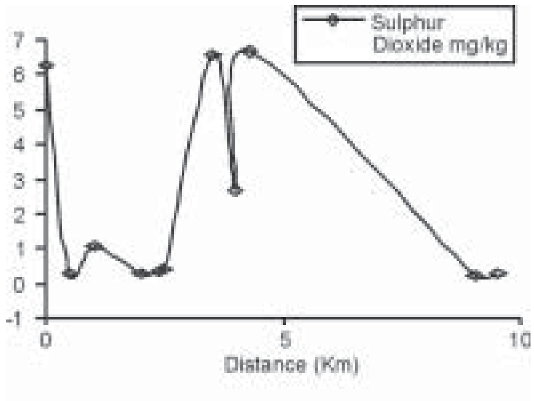

Fig. 3. Relationship between Sulphur dioxide in the soil and the distance from the plant

have higher values than the others. The Hot Mix Asphalt plant would be the reason why the samples near it have high sulphur dioxide. This could be attributable to the fact that sulphur dioxide is a rather more stable gas than the previous two, which respectively oxidizes to carbon dioxide and nitrogen dioxide readily in the presence of oxygen in the air.

Volatile Organic Compounds content of the soil ranged from an average value of 25.5 to 54.0 mg/kg. There is no significant difference between the samples near and those far from the plant (see Fig. 4). This is because the correlation coefficient value of 0.076 with resultant T-test value of 0.261 is not significant at 5% confidence level (Table value of 1.782). Thus, the asphalt plant has no significant impact on the Volatile Organic Content content of the soil around it.

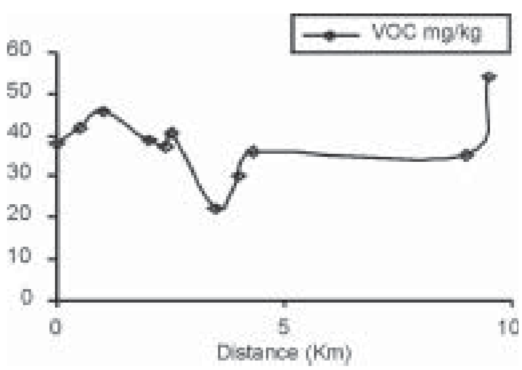

Fig. 4. Relationship between volatile organic compounds in the soil and the distance from the plant

Benzene content of the soil samples is highest near the plant. It ranges from 0.0 to 3.8mg/kg. The asphalt plant could be said to be responsible for the higher benzene content of samples near it. Traces of minute benzene found in samples from cell M and N that are farthest and are the control cells may be due to other sources. This assertion is confirmed by Figure 5 and the correlation coefficient and T-test values of –0.74 and –3.80 respectively. At 5% confidence level with a table value of 1.782, the result is not valid, which implies that correlation exist between Benzene values in the soil and distance from the Hot Mix Asphalt plant.

Toluene content of samples ranged from 4.20 to 10.80 mg/kg. There is no significant relationship between Toluene content of the soil and the distance from the Hot Mix Asphalt plant as shown in Figure 6. The correlation coefficient value is 0.32, while the T-test gave a value of 1.235: Thus, at 5% confidence value with a table value of 1.782 the result is not significant and consequently the conclusion is that the plant does not have any significant impact on the Toluene content in the soil.

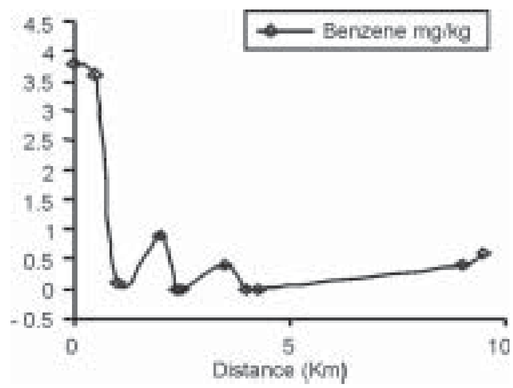

Fig. 5. Relationship between Benzene in the soil and the distance from the plant

Formaldehyde content of the soil samples ranged from 0.004 to 0.032mg/kg. Though no significant relationship between formaldehyde content and the distance from the plant could be established (Fig. 7), the amounts found in all the samples are negligible. With a correlation coefficient value of –0.31 and consequent T-test value of –1.129, the relationship between

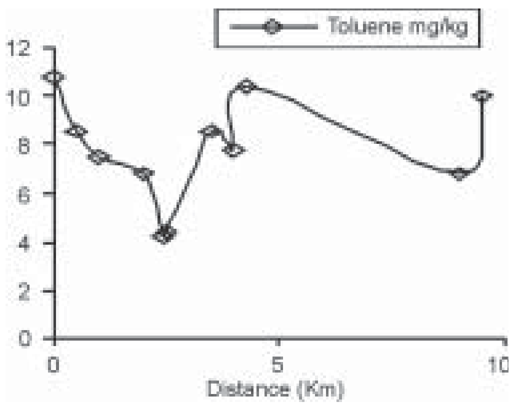

Fig. 6. Relationship between toluene in the soil and the distance the plant

Formaldehyde content in the soil and the distance from the Hot Mix Asphalt plant is not significant at 5% confidence level with a table value of 1.782. It is therefore asserted that the plant has no significant impact on the Formaldehyde content of the soil around it.

Cadmium levels in the soil ranged from 0.009 to 0.045 mg/kg. Figure 8 indicates that the soil samples closer to the Hot Mix Asphalt plant have higher Cadmium than those further away, although at close proximity to the plant the Cadmium values are rather low. However, the correlation value of –0.93 that gave a T-test value of –8.77 is not valid, implying that the relationship between Cadmium content in the soil and the distance from the plant is significant. It is therefore concluded that the Hot Mix Asphalt plant has significant impact on the cadmium content in the soil around it.

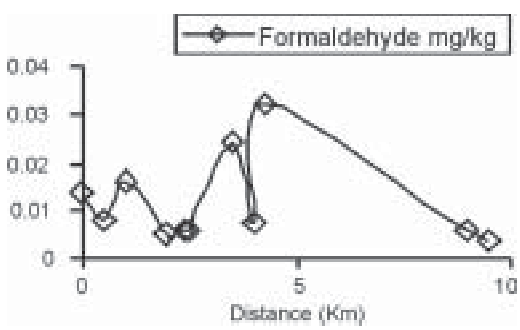

Fig. 7. Relationship between formaldehyde in the soil and the distance from the plant

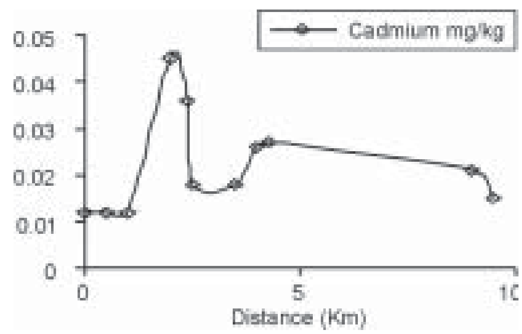

Fig. 8. Relationship between cadmium in the soil and the distance from the plant

The Impact on Vegetation

The vegetation around the Hot Mix Asphalt plant seems to be of the same consistency with those further away from it. The leaves are green with traces of yellowish colour on older vegetation. The analysis of some elements in the sample leaves taken shows the same range (see Table 3).

Total nitrogen content is higher in the sample nearest to the plant. However, nitrogen content of sample one (1) that is 8.5km away from the plant is higher than that of sample three (3) which is 1.5km away from the plant. Thus, the most logical assumption is that the Hot Mix Asphalt

Table 3: Result of vegetation test

S. No.	*Distance from HMA facility*	*Nitrogen (g/kg)*	*Phosphorous (g/kg)*	*Calcium (g/kg)*	*Magnesium (g/kg)*	*Sodium (g/kg)*	*Potassium (g/kg)*	*Sulphate (mg/kg)*
1.	8.50 km	0.93	0.108	0.48	0.08	0.19	0.17	1.44
2.	0.00 km	0.96	0.105	0.48	0.10	0.27	0.18	1.04
3.	1.50 km	0.82	0.100	0.45	0.06	0.09	0.15	1.21

Source: Laboratory Analysis 2002

plant has no impact on the vegetation around it. Vegetation is known to be unrivalled cleaner of the atmosphere. The vegetation around the plant absorbs a lot of the air pollutants emitted. It has been calculated that one hectare of wood can absorb 400kg of sulphur dioxide (Obaseki and Ohonba 1988).

To ascertain whether or not significant difference exist between nitrogen content in the samples taken, a statistical analysis (Analysis of Variance) was undertaken. The results (computed F value of 0.054 and table value of 3.55 at 5% confidence level) indicates that no significant difference exist in the nitrogen content of the vegetation samples taken. The conclusion is that the plant has no significant impact on the vegetation around it.

The Impact on Water

Table 4 shows the result of water analysis. The water sample taken from the borehole acted as the *control* sample. The borehole, which is over 80 meters deep, is located within the Hot Mix Asphalt plant premises. It is assumed that the plant will have little or no effect on its water quality. Analysis of the borehole water showed that it is fit as a public surface water supply source for domestic consumption. The content of the various elements tested for met with the World Health Organization (WHO 1971) standards for drinking water. For instance, pH level of 6.5 is within the acceptable standard of 6.5 to 8.5. Chlorine level of 0.36 mg/l is far below the limit of 250mg/l. Sulphate content is 0.32mg/l: This is also within the standard as the upper limit for Sulphate is 250mg/l. Calcium content is 0.19mg/l, a value which is less than WHO standard of 75mg/l. Magnesium content at 0.97mg/l is also within the limit (i.e. 1.0mg/l), for public surface water supply. Nitrogen content is 0.19mg/l. The World Health Organization's standard is 10mg/l, though it is desirable if nitrogen is totally absent. Chemical Oxygen Demand (COD) is 4.2mg/l while the World Health Organisation's standard is 4.0mg/l for drinking water. The value of 4.20mg/l is considered the fringe of tolerable limit.

Rainwater collected has higher amounts of all the elements tested for. The pH value of 5.40 indicates that it is slightly more acidic than the borehole water. While this may be acceptable for agricultural purposes, it falls short of required pH for drinking water, which by World Health Organisation's standard is in the range of 6.0 to 8.5. Chlorine level is the same with that of the borehole. Sulphate content is 1.04mg/l: Though this is insignificant when compared with World Health Organisation's standard, it is still higher than that of the borehole, which tends to indicate atmospheric pollution. This may result from the sulphur dioxide (SO_2) emitted by the HMA plant into the atmosphere.

Calcium and magnesium content of the rainwater are equally higher than those of the borehole water. This could be due to the presence of other pollutants in the atmosphere, as the Hot Mix Asphalt plant is not known to generate these elements. Chemical Oxygen Demand (COD) content at 6.10mg/l is also higher than that of the borehole water.

Nitrogen content of rainwater is 0.52mg/l. This is against 0.19mg/l recorded for the borehole water. The HMA plant is known to emit nitrogen oxide pollutant. That the rainwater passing through the atmosphere has a higher level of nitrogen, imply atmospheric pollution by the plant. However, a level of 0.52mg/l is rather insignificant when compared with World Health Organisation's standard of 10mg/l.

The water sample from Okpare creek was collected at a point that is about 200 meters south of the Hot Mix Asphalt plant. It is a running river and has a pH of 6.10. This makes it more acidic than the borehole water but less acidic than the rainwater. Chlorine content of 0.71mg/l is the highest of the three samples taken. This, however, is still within tolerable limits for public surface water supply and for agricultural uses.

Sulphate content at 0.65mg/l is higher than the 0.32mg/l recorded for bore hole water and

Table 4: Result of water constituent elements test (All parameters are in mg/l)

S.No.	*Sample description*	*pH*	*Chlorine*	*Sulphate*	*Calcium*	*Magnesium*	*Sodium*	*Potassium*	*COD*	*Nitrogen*
1.	Borehole	6.5	0.36	0.32	5.61	0.97	0.55	1.66	4.20	0.19
2.	Okpare creek	6.1	0.71	0.65	8.02	1.94	1.01	2.58	7.30	0.36
3.	Rain water	5.4	0.36	1.04	7.21	1.46	0.36	0.46	6.10	0.52

Source: Laboratory Analysis 2002

lower than 1.04mg/l recorded for rainwater. Though they are within tolerable limits, the fact that there are differences is indicative of an external influence. The Hot Mix Asphalt plant emits sulphur dioxide pollution that may be responsible for the presence of sulphate in the river water at a level higher than the borehole water content.

Nitrogen content is 0.36mg/l. This is also higher than the borehole water level of 0.19mg/l but lower than that of the rainwater at 0.52mg/l. This could also be attributed to the influence of the Hot Mix Asphalt plant that generates Nitrogen oxide pollution.

It is thus glaring that only the water from the borehole meets the acceptable limits by WHO standards for domestic use. The asphalt plant invariably has impact on the quality of water of the Opkare creek and rainwater. This impact is, however, not significant as the F value of 0.258 (Table value of 3.40 at 5% confidence level) is valid. This implies that no significant difference exist in the various constituent elements in the water samples taken.

The Impact on Human Health

According to the Nigerian Environmental Study Team (NEST 1991), chemicals discharged from occupational activities (such as Hot Mix Asphalt plant) could cause severe discomfort and misery and may cause cancers to animals and man after a long period of time of exposure. Apart from workers of the industry, members of the community in which the facility is located are also exposed to the hazard.

The inhaling of unclean air, which occurs as a result of emission of pollutants during production and discharge of input materials, may cause such ailments as acute bronchitis, common cold, pneumonia, emphysema and even asthma. Some of these ailments could be fatal.

During asphalt production, gaseous pollutants are emitted into the atmosphere. These pollutants, when inhaled continuously and absorbed by the lungs, reduce the oxygen carrying capacity of the blood and tolerance to exercise. It also impairs mental function and aggravates cardiovascular diseases. Prolonged exposure to carbon monoxide diminishes visual perception and the ability to perform intellectual task. Acute exposure to dust particles causes eye, nose and throat irritations while chronic exposure causes cancer.

However, there has been no reported case of general ill health by the workers. Perhaps the fact that the owners of the facility at Agbarha-otor has provided adequate Personal Protective Equipment (PPE) like coveralls, safety boots, safety helmets, nose mask, ear mufflers and eye goggles has mitigated the adverse effect on the workers. The facility is situated at about 3km from the nearest habitation, thereby reducing the possible effects on the health of the community members.

Another aspect of the impact on human health is noise pollution. The Hot Mix Asphalt plant in various ways generates noise. Firstly, during production when all the mechanical and electrical motors have to be switched on. Secondly, the heavy-duty vehicles that bring in the input materials and those that take away the finished Hot Mixed Asphalt create noise. Specifically when these heavy-duty vehicles are tipping their load, the noise level is very high. Thirdly, the standby electrical generator (power plant) that for now is the only source of power for the facility creates noise. It is used during production and at times when production is not on, to supply power for the offices and other uses.

The effect of noise on the comfort of the people around it need not be over emphasized. Exposure to high noise level can result in temporary or permanent impairment of hearing ability (Stocks 1994). However, the Agbarha-otor Hot Mix Asphalt plant owners may have thought of these and thus sited the facility far from human habitation to mitigate the effect of noise pollution. They have also provided ear mufflers to the workers to minimize the effect of noise on the work force.

Socio-economic Impact

The Abgarha-Otor Hot Mix Asphalt plant is a 180-tons/hour plant. By all standards, it is a big production outfit and would have a lot of social and economic impact on the neighbourhood. It employs a total of thirty- four (34) staff, made up of twelve (12) senior staff and twenty-two (22) junior staff. There are in addition to these, ad-hoc workers that are engaged from time to time. The number of the ad-hoc workers ranged from 4 to 15 depending on the nature of the job to be done. All the junior staff and about 60 % of the senior staff are indigenes of the locality. Thus the facility has contributed to generating employment for the indigenes. The workers spend about 80 % of their income in the community, thereby enhancing economic development in the area. The facility has also contributed to the improvement of roads within the locality

On the negative side, the plant has put pressure on some other facilities like housing. Apart from the plant workers, truck drivers that supply raw materials to the plant and those that take away finished products occasionally spend the night in the town. The upward increases in house rent is exacerbated by the housing needs generated by the location of the plant in the town. Also increased are the demand for power and portable water supply. These are however challen-ges that could herald massive infrastructural development in the area.

CONCLUSION AND RECOMMENDATIONS

Modern technology is extending stress on the environment, breaking some vital links in the web of physical and biotic potentials processes that maintain the ecological system in which man lives (Ahmed 2000). With improvement in techno-logy and the attendant increase in productivity, and enhanced comfort, man inadvertently destroys his nest. This is evident in the discharge of enormous quantities of pollutants into the environment. One of the sources of these pollutants is Hot Mix Asphalt Plant, which is required in all road construction or maintenance project.

Indeed, road-based transport is by far the most damaging land-based mode (Tolley and Turton 1995). For instance, the results of this research have shown that the Agbarah-Otor Hot Mix Asphalt facility has some limited impact on the soil, creek, and rainwater in its immediate environment. Though the quantities of the pollutant elements in the environment are low, (the plant has operated for just over a decade so far) no doubt more quantities will be deposited in the environment with more years of production. It is, therefore, necessary to put in place remedial measures that will ensure the sustainability of environmental quality in Agbarah-Otor and indeed other areas where Hot Mix Asphalt plants are located. One such measure is Pollution Emission Control: This involves the use of modern designs of Hot Mix Asphalt plant that incorporates pollution control devices. Another measure is to ensure that Hot Mix Asphalt plants are located far away from any area of human habitation. Perhaps of greater relevance is to ensure that Environmental Impact Assessment (EIA) is undertaken before the commencement of operation and successively during the period of operation.

REFERENCES

Ahmed YA 2000. Waste Generation and Management Techniques. In: HT Jimoh, IP Ifabiyi (Eds.): *Contemporary Issues in Environmental Studies*. Ilorin: Haytec Press and Pub. Co. Ltd., pp. 110 –117

Ajibade LT 2000. The Environmental Systems. In: HT Jimoh, IP Ifabiyi (Eds.): *Contemporary Issues in Environmental Studies.* Ilorin: Haytec Press and Pub. Co. Ltd., pp. 12 -19

Akinbamijo OB 2002. Dynamics of Environmental Relationships: The Gender Route to Sustainable Living. *The Journal of Urban and Environmental Research*, 2(1): 29-42.

Arosanyin GT 2000. Baseline Estimates of Environmental Costs of the Nigerian Road Transport System. In: HT Jimoh, IP Ifabiyi (Eds.): *Contemporary Issues in Environmental Studies.* Ilorin: Haytec Press and Pub. Co. Ltd., pp. 44-58

Billigton ET 1977. *Ecology Today*. London: Today Series, Kaye and Ward Ltd.

Ciammaichella E 2000. *Hot Mix Asphalt Facilities.* From www.baaqmd.gov/permit/handbook (Retrieved in March 2002)

FEPA 1991. *Guidelines and Standards for Environmental Pollution Control in Nigeria, Lagos, Nigeria.* Federal Environmental Protection Agency.

FMWH 1994. *Inventory of Federal Roads.* Abuja, Nigeria: Federal Ministry of Works and Housing. Highway Management Series Division.

Jeje LK, Adesina FA 1996. *Man and Environment: An Introductory Note*. Ede, Nigeria. Research, Evaluation, Resources and Development Consultants

Jimoh HI 2000. Man-Environment Interactions. In: HT Jimoh, IP Ifabiyi (Eds.): *Contemporary Issues in Environmental Studies.* Ilorin: Haytec Press and Pub. Co. Ltd., pp. 20-22.

Monkhouse TJ 1975. *Principles of Physical Geography.* London: Hodder and Stoughton.

NEST 1991. *Nigeria's Threatened Environment:A National Profile*. Ibadan: Nigerian Environmental Study Team.

Obaseki SO, Ohonba EA 1988. Environmental Impact of Steel Production. In: Pius O Sada, Francis O Odemerho (Eds.): *Environmental Issues and Management in Nigerian Development.* Ibadan: Evans Bros Nig. Pub Ltd. pp. 182-195.

Ogiehor IS, Omofomwan SI 1998. Environmental Impact Assessment for Sustainable Human Development: Evaluation of Federal Roads is Anambra State for Rehabilitation and Maintenance. In: Samson I Omofonmwan, Albert A Segynola (Eds.): *Environmental Management for Sustainable Human Development*. Ekpoma: Edo State University Library, Nigeria, pp. 187 –193.

Okafor SI 1988. *Introduction to Man-Environment Interaction*. Ibadan: External Studies Programme, Adult Education Department ,University of Ibadan Nigeria.

OSHA 2002. *Asphalt Fumes, Occupational Safety and Health Administration*. New York: U. S. Department of Labor, file//A:\giga\OSHA Priorities-Asphalt Fumes.htm. Retrieved in May 2002.

Stocks E 1994. *Open Cast Mining*. New York: Slippery Rock State College, MSS Information Corporation.

Tolley RS, Turton BJ 1995. *Transport Systems, Policy and Planning: A Geographical Approach*. New York: Longman. P. 263 & 311.

UNCED 1992. *Programme of Action for Sustainable Development*. Rio de Janeirio: Agenda 21.

Wilson AG 1981. *Geography and the Environment: System Analytical Methods.* Chichester: John Wiley and Sons.

WSDNR 2001. *Hot Mix Asphalt Plant Air Emission Inventory Guidance*. Wisconsin: State Department of Natural Resources From: www.envengstudies.com/ emission-inventory.htm (Retrieved in March 2002).