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# ENVIRONMENTAL AND HEALTH EFFECTS OF INDUSTRIAL AND VEHICULAR EMISSIONS IN LAGOS, NIGERIA

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**Abstract:** Air pollution increases health risks and has effects on the environment. In this study, investigation of the effects of vehicular and industrial emissions on human health was carried out by administering questionnaires in selected study areas in Lagos, Nigeria. Study areas selected included Ajah, Oregun, Marina and Epe which represent residential, industrial, commercial and control areas respectively. Physical and chemical properties of rain water from the study areas were also analyzed to determine the environmental effects of vehicular and industrial emissions. The study showed that respondents complained mostly about catarrh, headache and cough. Other health problems related to air pollution were also reported but at lower frequencies. The experimental analysis of rain water collected from the different study locations indicated that Ajah and Marina had lower pH values and higher levels of electrical conductivity, turbidity, nitrates, chlorides and free $CO_2$ than the control area. Oregun had the highest values of electrical conductivity, total acidity, calcium hardness, total hardness, nitrates and sulphates. Environmental effect of emissions is increased when industries exist in areas of high vehicular traffic.
**Keywords:** industrial air pollution; vehicular emissions; health risk; environment; Nigeria

## 1. INTRODUCTION

Pollution free atmosphere is a requirement for healthy living as several diseases can be linked to polluted air. Environmental pollution, however, results from several human activities associated with socio-economic development (Mikhailyuta et al., 2007). Poor air quality could increase respiratory ailments which include asthma and bronchitis (Kopnina, 2017). It may also increase the risk of cancer and other life-threatening conditions. Outdoor air pollution is a complex mixture of particulate matter ($PM_{10}$, $PM_{2.5}$) and gases. The particulate matter deposits in the human nasopharynx or in the bronchioles and alveoli of the human lung depending on the particle size (Hayes, 2008). Common gaseous pollutants in outdoor air include carbon monoxide (CO), nitrogen oxides ($NO_x$), sulphur dioxide ($SO_2$) and ground level ozone.

Vehicles have been identified as a significant source of urban air pollution. They have become increasingly important contributors of anthropogenic carbon dioxide and other greenhouse gases (HEI, 2010; Wargo et al., 2006). Faiz et al. (1990) particularly stated that there is a direct relationship between transport energy consumption and emissions from transport sources. Vehicular emissions vary with the vehicle age, type, operation, maintenance, exhaust treatment, fuel, wear of parts, and engine lubricants. It has been noted by Greenbaum (2013) that the emissions of several harmful substances from vehicle engines is not solely the result of the combustion process of gasoline and diesel fuel. The emissions result from the combination of engine design and fuel characteristics. Greenbaum (2013) also stated that analyses have indicated that a significant source of vehicular emissions is abrasion and wear of tyres and metallic components which result emissions of a variety of metals and carbon compounds. Meena and Omar (2015) carried out a chemical analysis of rain water to study the effect of vehicle emissions on human health within the Kurdistan region of Iraq. The study observed that some respondents suffered from asthma attacks, sleeplessness, heavy eye, headache and cough.

There are different industries classified based on their products and include iron and steel industry, textiles and leather industry, pulp and paper industry, petrochemicals and refineries, food processing, and chemical industries. The pollutants resulting from the industries are varied but the common air pollutant from the industries include sulphur dioxide ($SO_2$) which is emitted from industrial process and from fuel combustion. Other gas emissions from the industries include nitrogen oxides ($NO_x$), hydrocarbons (HC), carbon monoxide (CO), hydrogen sulphide ($H_2S$), toxic and organic chemicals (Orlova et al., 2015). Orlova et al. (2015) had investigated the air pollution from industrial plants by lichen indication. Thummajitsakul et al. (2015) and Dathong et al. (2014) also carried out similar studies. Dinrifo et al. (2010) investigated the physico-chemical properties of rain water from industrial areas. Guo et al. (2014) found that all air pollutants had significant short-term impacts on non-accidental mortality.

HEI (2010) presented a critical review of literature on emissions, exposure and health effects. Wargo et al. (2006) found from their work that air pollution exacerbates illnesses such as cardio-vascular disease, asthma, chronic obstructive pulmonary disease, lung cancer, and diabetes. Pandian et al. (2009) reviewed the effect of traffic, vehicle and road characteristics on vehicular emissions and noted that most studies have found that vehicular

exhaust emissions near traffic intersections are largely dependent on fleet speed, deceleration speed, queueing time in idle mode with a red signal time, acceleration speed, queue length, traffic-flow rate and ambient conditions. Afroz et al. (2003) reviewed the results of ambient air quality monitoring and studies related to air pollution and health impacts and noted that strategies such as recycling, changes in engineering control equipment and air cleaning systems have been applied to improve air quality.

In Nigeria, there has been a growing importation of used vehicles which aid the degradation of the environment despite the global attempt to reduce environmental problems caused by transport technology (Ajayi and Dosunmu, 2002; Atubi, 2015). Osuntogun and Koku (2007) studied the environmental impacts of urban road transportation in south-western states of Nigeria by conducting interviews, estimating the air quality indicators and performing analyses on blood samples. The study revealed that responders suffered from air pollution related diseases such as headaches, loss of vision, anaemia, forgetfulness and fatigue.

Ndoke and Jimoh (2005) carried out a study on the impact of traffic emission on air quality in Minna which is a developing city in Nigeria and found that it was below the maximum level prescribed by the United States Environmental Protection Agency. Ayodele and Abubakar (1998) discovered trace metals including lead, chromium and copper correlated with industrial activities in a study carried out on rain water in the semi-arid region of Kano, Nigeria. From an assessment of vehicular emissions and health impacts in Jos, Nigeria, Alfred and Hyeladi (2013) found that there is a significant relationship between vehicle increase, high exposure to vehicle emissions and increase in air pollution related diseases.

Ojolo et al. (2007) studied the effects of vehicle emissions on human health in Nigeria using four locations in Lagos, Nigeria. The study also observed the physical effects on vegetations, buildings and structures and concluded that the type of fuel, presence of industries and concentration of traffic determine the impacts of emissions on the ecosystem. Pascal et al. (2016) investigated the seasonal variability of carbon monoxide in Imo State, Nigeria using an air monitoring instrument. It was observed that there was significant variation of the air pollutant during the day, and also during wet and dry seasons. Abam and Unachukwu (2009) carried out a study to investigate vehicular emissions in selected area in Calabar, Nigeria and concluded that transport-related pollution was significant with possible severe health consequences. The potential harmful effects of the vehicular and industrial air pollutants on health and environment are presented in Table 1.

Table 1: Potential harmful effects of the main automobile exhaust pollutants on health and environment

| Pollutant | Health effect | Environmental effect |
|---|---|---|
| Carbon monoxide (CO) | It can impair concentration and neuro-behavioural function. Asphyxia leading to heart and nervous system damage. It is lethal at high doses. | Greenhouse gas contributing to global warming. |
| Ozone (O3) | Irritates the eyes and air passages. Increases the sensitivity of the airways to allergic triggers in people with asthma. May increase susceptibility to infection. | Oxidants to plants, impairs growth and maturation. |
| Sulphur oxides (SOx) | Bronchoconstriction, chronic bronchitis, chronic obstructive lung disease. | Acid rain. Haze. |
| Nitrogen oxides (NOx) | Worsens asthma. Airway injury, pulmonary edema, impaired lung defences. | Acid rain. Haze. Eutrophication leading to alteration of aquatic ecosystem. Ground level ozone precursor. |
| Hydrocarbons (HC) | Low molecular weight compounds cause eye irritation, coughing and drowsiness. High molecular weight compounds can be mutagenic or carcinogenic. | Contribution to ozone formation, odours and some direct effect on buildings and plants. |
| Lead (Pb) | Impairs the normal intellectual development and learning ability of children. | Ground water pollution and particles in air. |

It is important to study the health and environmental effects particularly when industrial emissions coexist with vehicular emissions. Most studies have investigated the vehicular emissions or industrial emissions individually and have not considered when the two sources of air pollutants coexist. In this study, the effects of air pollution from vehicles and industries on the environment and human health are investigated.

## 2. MATERIALS AND METHOD

### Description of Study Area

Lagos state is in the south-western part of Nigeria and is located on latitude $6.3°N$ and longitude $3.3°E$. The state is surrounded by a water bodies – lagoon and ocean, and it is resident within the tropical rain forests. The temperature of the region ranges from $27°C$ to $36°C$ during the dry season, which is from November to March, and $20°C$ to $25°C$ in the wet season from April to October. Lagos state is densely populated with an estimated population of over 23,305,971 people and population density of 812,741 (Lagos Bureau of Statistics, 2012). The state is also a commercial hub and a gateway to goods and services into Nigeria.

Four cities within Lagos state have been selected as sample areas. They include Ajah, Oregun, Marina and Epe. Ajah is an urban residential area with moderate commercial activities, moderate use of electricity generators and moderate traffic. Oregun is an industrial and commercial area with automobile workshops, a bus park, factories with a high dependence on electricity generators and high traffic. Marina is largely a commercial area with heavy traffic of vehicles particularly in the early mornings and evenings. Epe is taken as the control area due to its comparatively very low population, rural setting, low traffic.

It had been pointed out that vehicular traffic is an index to determine the extent of vehicular emission. A vehicular count was conducted by physical count of vehicles at selected intersections within the study areas by Busari (2011). The count was made in the morning, afternoon and evening over a period of three days at each study area. The average vehicular count per hour at the study areas, taken as the representative vehicular traffic of the area, is presented in Table 2.

Table 2: Average vehicular count per hour at the study areas (Busari, 2011)

| Type of vehicle | Ajah | | | Oregun | | | Marina | | | Epe | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Morn | After | Even | Morn | After | Even | Morn | After | Even | Morn | After | Even |
| Cars | 1084 | 667 | 932 | 750 | 531 | 776 | 2450 | 1694 | 2086 | 228 | 156 | 102 |
| Buses | 491 | 246 | 397 | 312 | 258 | 357 | 787 | 544 | 648 | 36 | 11 | 5 |
| Trucks | 85 | 97 | 61 | 60 | 78 | 42 | 70 | 36 | 31 | 14 | 8 | 2 |
| Motorcycles | 1057 | 795 | 928 | 1884 | 1311 | 1779 | 1326 | 982 | 1032 | 942 | 516 | 532 |
| Total | 2717 | 1805 | 2318 | 3006 | 2178 | 2954 | 4633 | 3256 | 3797 | 1220 | 691 | 641 |

## Methods of investigation

The study was carried out using questionnaires and experiments. Questionnaires were used in the study of the effects of vehicular and industrial emissions. Environmental effects of the emissions were investigated by laboratory experiments.

### a. Questionnaires

Questionnaires were prepared and administered to individuals within each study area. The questionnaires were designed to investigate the health problems faced by the respondents in the study areas. The questionnaires were then analysed to determine health effects of the vehicular and industrial emissions based on the health problems reported by the respondents.

### b. Experimental study

Rain water was carefully collected from the four study areas to prevent contamination from run-off water from roof or ground/road splashes. The collected samples were analysed to determine the pH, electrical conductivity, colour, turbidity, total acidity, total hardness, calcium hardness, magnesium hardness, nitrate, sulphate, chloride, free $CO_2$, and lead. Standard laboratory test procedures described by Dinrifo et al. (2010), Ojolo et al. (2007) and Meena and Omar (2015) were used in the analyses of the rain water samples at the analytical laboratory of the University of Lagos, Nigeria.

## 3. RESULTS AND DISCUSSIONS

## Health effects of emissions

The health effects of the vehicular and industrial emissions were investigated by the use of questionnaires. Tables 3 and 4 shows the spread of respondents within the study locations. Table 3 shows the respondents classified by age and sex whilst Table 4 shows the respondents classified by occupation and sex.

Table 3: Classification of respondents by age and sex

| Study area | 15-25 | | 25-35 | | 35-45 | | 45-60 | | Above 60 | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F | All |
| Ajah | 17 | 6 | 16 | 18 | 14 | 6 | 9 | 7 | 5 | 1 | 61 | 38 | 99 |
| Oregun | 15 | 1 | 20 | 9 | 23 | 6 | 8 | 2 | 1 | 2 | 67 | 20 | 87 |
| Marina | 10 | 4 | 28 | 11 | 10 | 11 | 4 | 3 | 1 | 1 | 53 | 30 | 83 |
| Epe | 5 | 0 | 18 | 7 | 20 | 6 | 1 | 1 | 0 | 0 | 44 | 14 | 58 |
| Total | 47 | 11 | 82 | 45 | 67 | 29 | 22 | 13 | 7 | 4 | 225 | 102 | 327 |

Table 4: Classification of respondents by occupation and sex

| Respondent | Ajah | | Oregun | | Marina | | Epe | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | All |
| Corporate employees | 14 | 12 | 20 | 9 | 16 | 7 | 9 | 1 | 59 | 29 | 88 |
| Traders | 18 | 18 | 27 | 7 | 22 | 14 | 11 | 8 | 78 | 47 | 125 |
| Transporters | 8 | 2 | 9 | 0 | 6 | 0 | 10 | 0 | 33 | 2 | 35 |
| Others | 21 | 6 | 11 | 4 | 9 | 9 | 14 | 5 | 55 | 24 | 79 |
| Total | 61 | 38 | 67 | 20 | 53 | 30 | 44 | 14 | 225 | 102 | 327 |

The duration of exposure of correspondents to air pollution was determined by the period during which the respondents spent outdoors, either in or around vehicles or performing other activities. The duration of

exposure of the respondents is presented in Table 5. As observed, 55% of the respondents were exposed to emissions for periods ranging from 5 to 10 hours daily while 39% of the respondents were exposed for less than 5 hours.

Table 5: Duration of exposure of respondents per day

| Study area | < 5 hours | | 5 – 10 hours | | >10 hours | | Total | |
|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F |
| Ajah | 19 | 20 | 40 | 17 | 2 | 1 | 61 | 38 |
| Oregun | 21 | 7 | 35 | 11 | 11 | 2 | 67 | 20 |
| Marina | 27 | 12 | 24 | 17 | 2 | 1 | 53 | 30 |
| Epe | 18 | 2 | 25 | 12 | 1 | 0 | 44 | 14 |
| Total | 85 | 41 | 124 | 57 | 16 | 4 | 225 | 102 |

Table 6: Health problems reported by respondents from study areas

| Health problem | Study area | Corporate employee | | Traders | | Transporters | | Others | |
|---|---|---|---|---|---|---|---|---|---|
| | | M | F | M | F | M | F | M | F |
| Catarrh | Ajah | 10 | 8 | 16 | 12 | 8 | 2 | 4 | 4 |
| | Oregun | 12 | 7 | 13 | 8 | 2 | 0 | 10 | 2 |
| | Marina | 6 | 5 | 9 | 5 | 3 | 0 | 6 | 4 |
| | Epe | 5 | 2 | 7 | 5 | 5 | 0 | 2 | 5 |
| Head ache | Ajah | 7 | 8 | 5 | 8 | 5 | 2 | 1 | 6 |
| | Oregun | 12 | 7 | 5 | 3 | 5 | 0 | 6 | 3 |
| | Marina | 5 | 3 | 8 | 6 | 2 | 0 | 8 | 5 |
| | Epe | 5 | 2 | 0 | 5 | 6 | 0 | 0 | 2 |
| Cough | Ajah | 6 | 5 | 5 | 5 | 2 | 0 | 5 | 6 |
| | Oregun | 11 | 2 | 4 | 4 | 5 | 0 | 6 | 4 |
| | Marina | 2 | 1 | 6 | 4 | 3 | 0 | 7 | 3 |
| | Epe | 2 | 3 | 7 | 5 | 3 | 0 | 5 | 1 |
| Sleeplessness | Ajah | 2 | 4 | 5 | 1 | 4 | 1 | 0 | 2 |
| | Oregun | 4 | 3 | 3 | 5 | 1 | 0 | 2 | 2 |
| | Marina | 1 | 0 | 3 | 7 | 3 | 0 | 2 | 3 |
| | Epe | 0 | 0 | 2 | 3 | 3 | 0 | 2 | 2 |
| Sore throat | Ajah | 3 | 2 | 7 | 4 | 2 | 0 | 1 | 0 |
| | Oregun | 3 | 2 | 3 | 0 | 2 | 0 | 1 | 0 |
| | Marina | 0 | 2 | 6 | 0 | 2 | 0 | 1 | 2 |
| | Epe | 1 | 0 | 0 | 1 | 2 | 0 | 1 | 1 |
| Heavy eye | Ajah | 2 | 5 | 5 | 8 | 2 | 0 | 0 | 1 |
| | Oregun | 1 | 3 | 2 | 0 | 2 | 0 | 4 | 2 |
| | Marina | 1 | 2 | 5 | 4 | 5 | 0 | 3 | 4 |
| | Epe | 0 | 0 | 3 | 4 | 1 | 0 | 0 | 3 |
| Asthma | Ajah | 4 | 2 | 6 | 4 | 2 | 0 | 2 | 2 |
| | Oregun | 2 | 3 | 2 | 4 | 2 | 0 | 2 | 0 |
| | Marina | 0 | 0 | 5 | 4 | 4 | 0 | 2 | 1 |
| | Epe | 0 | 1 | 3 | 0 | 1 | 0 | 2 | 0 |
| Itching | Ajah | 3 | 3 | 8 | 6 | 2 | 2 | 1 | 2 |
| | Oregun | 4 | 2 | 4 | 3 | 1 | 0 | 0 | 0 |
| | Marina | 2 | 2 | 4 | 4 | 2 | 0 | 1 | 3 |
| | Epe | 1 | 0 | 5 | 2 | 3 | 0 | 0 | 2 |

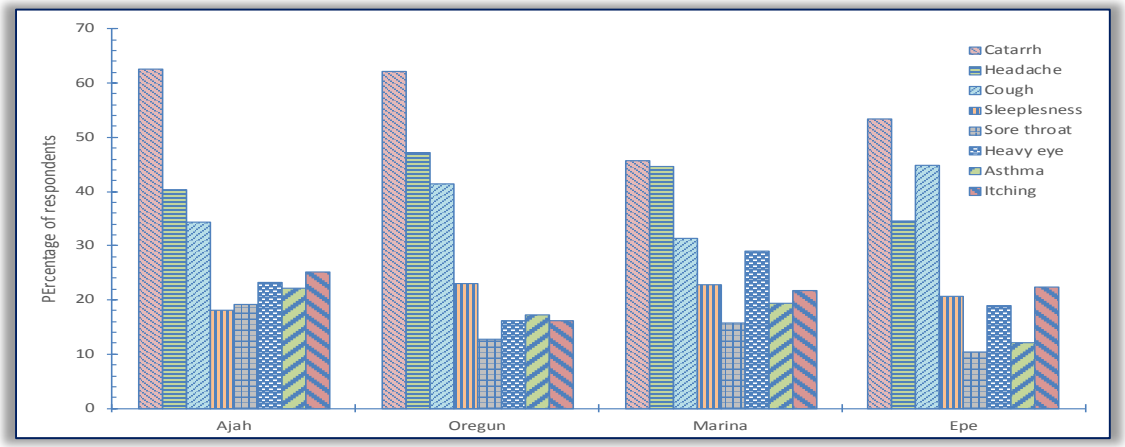


Figure 1: Graphical analysis of the health problems reported by respondents from study areas

The health problems reported by the respondents are presented in Table 6 and a graphical analysis in Figure 1. The health problems include catarrh, headache, coughing, sleeplessness, sore throat, heavy eye, asthma attacks and itching. As observed from the figure, respondents from all study areas commonly indicated that they suffer frequently from catarrh, headache and cough. In Ajah, 63% of the respondents reported that they frequently had coughs while the percentage of respondents with similar complaints in Oregun, Marina and Epe were 62%, 46% and 53% respectively. For headache, the percentage of respondents who reported headache were 40%, 47%, 45% and 34% respectively for Ajah, Oregun, Marina and Epe. Cough was reported by 34% of respondents in Ajah, 41% in Oregun, 31% in Marina and 45% in Epe. Other health related issues which were reported in Ajah, Oregun, Marina and Epe include sleeplessness (18%, 23%, 23%, 21%), sore throat (19%, 13%, 16%, 10%), heavy eye (23%, 16%, 29%, 19%), asthma (22%, 17%, 19%, 12%) and itching (25%, 16%, 22%, 22%).

### Rain water analysis

The results for the rain water analysis are presented in Table 7. The table shows results for the pH, electrical conductivity, colour, turbidity, total acidity, total hardness, calcium hardness, magnesium hardness, nitrate, sulphate, chloride, free $CO_2$, and lead.

Table 7: Results of rain water analysis

| Parameter | Ajah | Oregun | Marina | Epe |
|---|---|---|---|---|
| pH | 6.13 | 7.22 | 5.76 | 7.43 |
| Electrical Conductivity ($\mu Scm^{-1}$) | 27.2 | 51.5 | 18.6 | 14.8 |
| Colour | Colourless | Colourless | Colourless | Colourless |
| Turbidity ($FTU$) | 5.0 | 2.0 | 8.0 | 2.0 |
| Total acidity ($mg/l, CaCO_3$) | 8.0 | 12 | 6.0 | 6.0 |
| Magnesium hardness ($mg/l, CaCO_3$) | 2.0 | 2.0 | 5.0 | 2.0 |
| Calcium hardness ($mg/l, CaCO_3$) | ND | 22.0 | ND | ND |
| Total hardness ($mg/l, CaCO_3$) | 2.0 | 24.0 | 5.0 | 2.0 |
| Nitrate, $NO_3^-$ ($mg/l$) | 0.17 | 0.42 | 0.13 | 0.06 |
| Sulphate, $SO_4^-$ ($mg/l$) | 2.0 | 3.0 | 2.0 | 2.0 |
| Chloride, $Cl^-$ ($mg/l$) | 16.0 | 10.0 | 12.0 | 8.0 |
| Free $CO_2$ ($mg/l$) | 0.04 | 0.02 | 0.02 | ND |
| Lead, $Pb$ ($mg/l$) | ND | ND | ND | ND |
| ND = Not detected | | | | |

The pH of rain water is influenced by the ion concentration of nitrates, sulphate and carbonate. Rain water from Ajah and Marina had lower pH values than Oregun and Epe indicating presence of acids. However, as explained by Meena and Omar (2015), there may be a reaction of sulphuric and nitric acids with alkaline carbonates in particulate matter which may result in neutral or alkaline pH. This may be the reason why Oregun, being an industrial area, has a pH value slightly above neutral. The high traffic flow in Marina, which translates to higher emissions, may have resulted in the lower pH value compared to Ajah which has lesser traffic flow.

The presence of ionized substances (nitrate, sulphate, chloride and phosphate anions or sodium, magnesium, calcium, iron, and aluminium cations) determines the electrical conductivity of the rain water (Meena and Omar, 2015). The electrical conductivity of rain water from Oregun, an industrial area, is $51.5\ \mu S/cm$ which is higher than the values obtained for other areas. The electrical conductivity of rain water from Epe, the control area, was the least. Electrical conductivity of rain water from Ajah, a residential area, was higher than that from Marina, a commercial area.

The acidity levels of rain water from Oregun had the highest value followed by Ajah. Rain water from Marina and Epe had similar levels of acidity. The results also show that the magnesium hardness, calcium hardness, total hardness, nitrate and sulphate concentration levels in rain water from Oregun was much higher than from other regions. This may be due to emission from the factories present within the region. The sulphate concentration levels in rain water from Marina and Ajah are comparable to that obtained from Epe. Whilst the nitrate concentration levels in rain water from Ajah and Marina may be comparable, they are higher than that obtained from Epe, the control area.

## 4. CONCLUSIONS

The study investigated the influence of vehicular and industrial emissions on human health and the environment. Investigation on the human health was carried out by administering questionnaires at selected cities in Lagos, Nigeria. Cities included Ajah (residential area), Oregun (industrial area), Marina (commercial area) and Epe (control area). The study showed that respondents complained mostly about catarrh, headache and cough. Other health problems related to air pollution reported were sleeplessness, sore throat, heavy eye, asthma and itching. The experimental analysis of rain water collected from the different study locations indicated that vehicular emissions in Ajah and Marina, which are characterised by high vehicular traffic, has

effects on the environment. Also, Oregun, an industrial area, may have been the most affected area due to its high vehicular traffic coupled with industrial activities.

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