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Environmental Pollution and Refinery Operations in an Oil Producing Region of Nigeria: A Focus on Warri Petrochemical Company.

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Abstract: *The environment is considered as man's important asset that must be protected for his life support. Unfortunately, the situation is different where oil refinery and petrochemical plants operate. Environmental pollution in these areas poses serious threat to the ecosystem, often with undesirable effects. This paper, therefore, takes a look at the refinery operations in Warri Petrochemical Company, Nigeria (WPCN). The study adopts simple descriptive statistics in data analysis and discovers the prevalence of gas flaring, noise and vibrations as well as soil contaminations with liquid and solid waste disposal from the refinery. Policy recommendations are set forth based on research findings with a view to minimizing pollution in the study area.*
Keywords: *Environment, Pollution, Noise, Gas flaring, Refinery operations*

I. Introduction

Environment is the surrounding in which man or organization operates. It comprises of air, water, land, natural resources, flora, fauna, humans and their interrelations. In reality, it is the totality of the physical and biological surrounding in which man's life and work are conducted or where animals and plants species are sustained (Azubuike, 2010). Over the last two centuries, human activities have transformed the chemistry of earth's water and air, altered the face of earth itself, and reshaped the web of life. People have changed the environment in ways they never had in pre-modern times – for example, devastating the natural habitats and wildlife with pollutions from industries.

Although industrialization is vital to the nation's economic development, industries are implicated as some of the major contributors to environmental degradation problems in the country. Against the principles of sustainable development, uncontrolled industrial practices in Nigeria have led to unacceptable high levels of harmful and toxic substances in the air, water (ground and surface) and land. Pollution which is the act of making the state and conditions of an environment unhealthy and unbearable has severe effect on man and the ecosystem. Oil industry pollution arises from a variety of sources. The notable sources of pollution in Warri, Delta State are seismic surveys, noise and vibration, poor waste disposal and gas flaring (Fatunmbi, 2003).

Oil or petroleum refinery is an industrial process plant where crude oil is processed and refined into more useful petroleum products, such as gasoline, diesel fuel, asphalt base, heating oil, kerosene and liquefied petroleum gas. Oil refineries are typically large sprawling industrial complexes with extensive pumping running throughout, carrying streams of fluids between large chemical processing units. The crude refining process in the oil refinery (WRPC) releases numerous chemicals into the atmosphere daily. Consequently, there are substantial air pollution emissions and a notable odor which normally accompanies its operations. Aside from air pollution impacts there are also wastewater concerns, risks of industrial accidents such as explosion and industrial noise.

Gas flaring is a major source of pollution at the WRPC which has tremendous effect on the ecosystem. The gas flare is the only pollution that is visible to individuals living close to the refinery, particularly in Ubeji, Udu and Effurun communities. Gaseous wastes are emitted everyday through the flaring gas point into the atmosphere. This is as a result of regular refining and processing operations in the fuel plants. The flare only goes off when it is intentionally switched off for maintenance. At the entrance of the refinery, a thick black smoke is usually seen protruding into the atmosphere. This escalates when combustion is at its peak in the fuel plants creating a depressed environment engulfed by pollution. Processing operations in the plant also generate noise which is another source of pollution as machines and equipments are constantly running. Some of these machines aid the refining and processing of crude product and cooling of hot pipes to prevent them from overheating.

This study is limited to gas flare, industrial noise and vibrations and soil contamination that occur in Warri Refining and Petrochemical Company which is one of the refineries in Nigeria currently processing and refining crude oil into finished product for national and international use. The aim of study therefore, is to assess the effect of Warri refinery processing plant operations on the environment of the host community. The research

objectives are to: (i) identify the type of refinery, (ii) investigate the refinery operational methods, (iii) examine the level of industrial pollution in the study area, and (iv) assess the effects on the ecosystem.

II. Review of Literature

The environment we live in is exposed to different forms of pollutant. Pollutants are substances that have the capacity to cause harm to living organisms. They comprise of organic pollutants (compounds containing carbon and hydrogen and elements of oxygen, sulphur and phosphorus) and inorganic pollutants (carbon monoxide and carbon dioxide) (Notoma, 2010). They contaminate the environment when they are introduced in an amount that can cause instability, disorder, harm or discomfort to the ecosystem. Their common effects are the incalculable damage to aquatic life, agriculture and human health. Agreed that environmental pollution also results from natural causes such as volcanic eruptions, majority are caused by human activities. Pollution can take the form of chemical substances, or energy, such as noise, heat, or light (Azubike, 2010).

Engelking (2009) considers pollution as contamination of the earth's environment with materials that interfere with human health, the quality of life, or the natural functioning of the ecosystems (living organisms and their physical surroundings). Notoma (2010) regards pollution as the introduction of any substance or stressor, in such quantity and characteristics for such duration that a deleterious effect is produced on the biota in terms of their viability, relative abundance, health, mortality, etc. Many of the gases emitted by refineries are harmful to humans, and can cause permanent damage and even death. They can cause respiratory problems such as asthma, cough, chest pain, skin irritation, headaches, and cancers. The young children and the elderly are usually the worst hit.

Crude oil contains relatively high quantities of sulphur. When crude oil is heated at the refinery to produce fuel, the sulphur is converted into a gas called Sulphur dioxide (SO_2). This is a colourless gas with an offensive smell, like rotten eggs. Exposure to very high concentrations of SO_2 (particularly during accidental leakage at a refinery) can result in painful irritation of the eyes, nose, mouth and throat, difficulty in breathing, nausea, vomiting, headaches and even death. Some of the health effects from daily exposure to the gas are tight chests, worsening of asthma and lung disease, and narrowing of air passages in the throat and chest – a situation that provokes asthma attacks.

Noise is another pollution source that is common in the refinery. This occurs from machines like dryers and boilers, leaking pressure pipes, truck and crane movement, worn out machines and plant operations. Noise has been traditionally defined as "unwanted or disturbing sound". Measured in decibels, noise intensity can range from zero (the quietest sound the human ear can detect) to over 160 decibels. It becomes unwanted when it either interferes with normal activities such as sleeping, conversation, or disrupts or diminishes one's quality of life (Wikipedia, 2012). Sounds are produced by objects that vibrate at a rate that the ear can detect. Most humans can hear sounds between 20 and 20,000 hertz, unlike dogs that can hear high-pitched sounds up to 50,000 hertz. High-frequency sounds tend to be more hazardous and more annoying to hearing than low-frequency sounds. The fact that it cannot be seen, tasted or smelled explains why it has not received as much attention as other types of pollution, such as air pollution or water pollution.

The damage caused by noise pollution is related to the intensity of the sound, or the amount of energy it has. Field, (1993) opines that noise pollution affects both health and behavior of human. Many studies have revealed that extended exposure to noise pollution may cause auditory and nonauditory disorders, such as temporary or permanent hearing loss (Yildirim et al., 2007; Keipert, 2008), sleep disruption (Freedman et al., 1999; Freedman et al., 2011), vertigo, agitation, weariness, hypertension, gastrointestinal system problems (including gastric and duodenal ulcer), cardiac arrhythmia, nervous and psychic disorders (Van Kempen et al., 2002; Ising and Kruppa, 2004; Penny and Earl, 2004; Roozbahani et al., 2009)

Pollution exists in many forms and affects many different aspects of Earth's environment. As observed by Engelking (2009), "point-source" pollution comes from specific, localized, and identifiable sources, such as sewage pipelines or industrial smokestacks while "non-point-source" pollution comes from dispersed or uncontained sources, such as contaminated water runoff from urban areas or automobile emissions - the effects of which may be immediate or delayed. Primary effects of pollution occur immediately after contamination occurs, such as the death of marine plants and wildlife after an oil spill at sea. Secondary effects may be delayed or may persist in the environment into the future, perhaps going unnoticed for many years.

Sewage, industrial wastes, and agricultural chemicals such as fertilizers and pesticides are the major causes of water pollution. Water runoff carries chemicals such as phosphate and nitrates from agricultural fields and discharges into lakes, streams, and rivers. These combine with the phosphate and nitrate from sewage to speed the growth of algae (a plantlike organism). The water body many then become choked with decaying algae, which severely depletes the oxygen supply. Such pollution makes streams, lakes and coastal waters unpleasant to sight, smell and swim in. Fish harvested from polluted waters may be unsafe to eat. People who ingest polluted water can become ill, and, with prolonged exposure, may develop cancers or bear children with birth defects (Hart, 2009).

Solid waste is a source of pollution that can cause death, illness, or injury to people or destruction of the environment if improperly treated, stored, transported, or discarded. Such waste can be considered hazardous if it is ignitable (capable of burning or causing a fire), corrosive (able to corrode steel or harm organisms because of extreme acidic or basic properties), reactive (able to explode or produce toxic cyanide or sulfide gas), or toxic (containing substances that are poisonous). In summary, solid waste may be deadly or harmful to people or the environment and tend to be persistent in nature (Engelking, 2009).

Soil pollution is a buildup of toxic chemical compounds, salts, pathogens (disease-causing organisms), or radioactive materials that can affect plant and animal life. Unhealthy soil management methods degrade soil quality, cause soil pollution, and enhance erosion. Soil pollution can arise from a number of sources, including when farmers use an excessive amount of fertilizer and other chemicals on their land. Often soil pollution arises from the spilling or leaking of waste into the ground, such as an oil spill, or seepage from a landfill or even radioactive contamination (Gresham, 2012). Damage to an underground tank that is storing toxic chemicals can also be the source of the problem. Polluted soil can be a serious threat to human who come in contact with the soil or eat food grown in it. Sometime soil pollution can contribute to the pollution of water. This occurs through surface runoff, often when it rains and polluted soil is carried to nearby bodies of water.

III. The Study Area

Delta State is an oil producing region situated in the Niger Delta and in the South-South geo-political zone of Nigeria with a population of 4,098,291 (FGN, 2007). The state is made up of twenty-five Local Government Areas and it has a total land area of 16,842km^2 of which more than 40% is covered by water. Delta state lies between Longitude 5^o 00' and 6^o 45$^{'}$East and ude 5^o 00' and 6^o 30$^{'}$ North of the equator. The state borders Edo State in the North, Ondo State in the North West, Anambra and Imo States in the East, and Bayelsa State in the South. It has approximately 122 kilometers of coastline bound by the Atlantic Ocean in the South and South West.

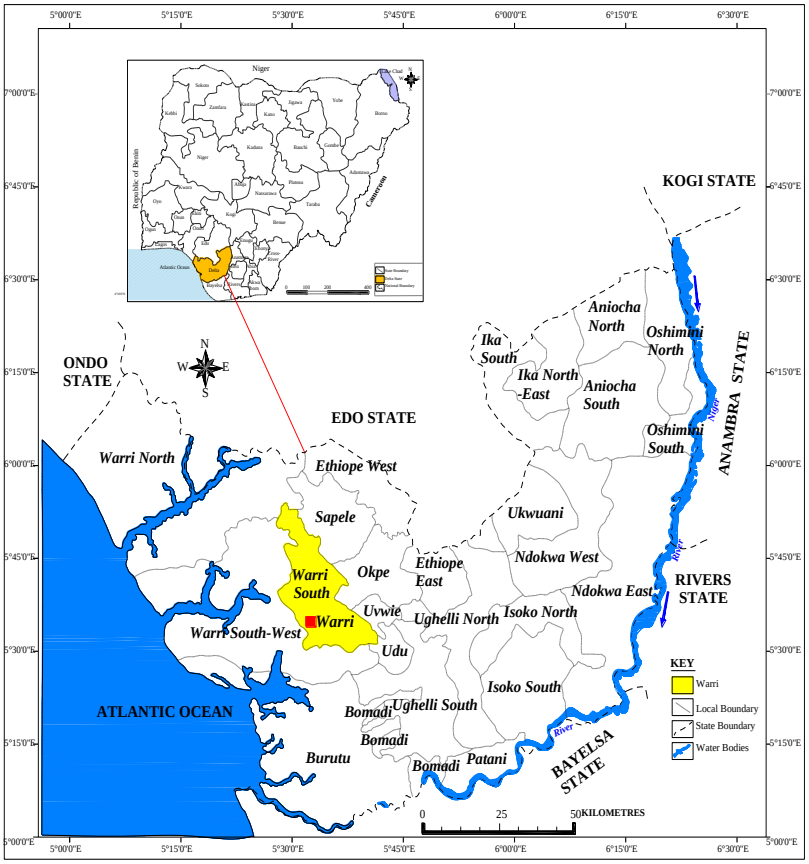

Fig 1: Warri in the Regional Setting

Source: Ministry of Lands and Housing, Delta State, Nigeria

Warri is a major oil city and, indeed, the economic nerve and the most populated in the southern part of the state. In the city, are locations of major oil and gas industries such as Shell, Chevron, Texaco, Halliburton and a host of others. Warri Refinery and Petrochemical Company (WRPC) is located in Ubeji community in Warri on a coordinate of 5^o 32'N and 5^o 41'E. It shares boundaries with the Nigeria Gas Company (NGC) in the North

and Petroleum and Pipeline Marketing Company (PPMC) in the South. WRPC is a big refinery that occupies a total land area of 1,104,014 hectares in Ubeji area of the city.

The WRPC is one of the eleven subsidiaries of the Nigerian National Petroleum Corporation (NNPC) created in 1988 in the wake of the NNPC commercialization exercise. The mission of this subsidiary (wholly owned by the NNPC) is to efficiently and profitably process crude oil into petroleum products through effective resource utilization, while exploiting new business opportunities. The company serves the dual role of fuel plant (refinery) and petrochemical plant (polypropylene and carbon black). The refinery processes two domestic crude oils: Chevron Escravos Crude Oil and the Shell oil at Ughelli Quality Control Centre (UQCC). It also produces liquefied petroleum gas for cooking; Dual Purpose Kerosene (DPK) used either as domestic kerosene or as Jet fuel; and Automotive Gas Oil (AGO) for automobiles.

The available facilities in the refinery can be classified into two broad categories namely: the primary and secondary processes. The primary process uses distillation principles to separate crude oil into intermediate and some finished products while the secondary process uses catalyst principles to convert the intermediate to higher quality finished and value-added petrochemical products. The marketable products from the facilities are: Liquefied Petroleum Gas (cooking gas), Petroleum Motor Spirit (Petrol), Kerosene (for domestic and aviation use), fuel oil, Polypropylene Pellets (Nipolene) and carbon Black Pellets.

IV. Data and Methods

Data for this study was generated through well-structured questionnaires which were administered on the host community (Ubeji) and heads of refinery operations at the WRPC. The specifically targeted operation units are: the Reforming, Topping and the Fluid Catalytic/Cracking unit as well as the Control room where noise, gas, Fluid and solid wastes are generated. The questionnaires contained close-ended questions with pre-coded alternatives meant to ascertain level of pollution and the management by WRPC and the effect on the host community. The authors administered the questionnaires through face-to-face contact with the officials and residents of Ubeji community for two weeks in March, 2012. A total of 200 respondents were randomly selected for interview, while other relevant information were gathered from texts, seminars, reports, internet and observations made at the project site in terms of gas flare, the liquid flow, dump site, etc. Data was processed with computer using Statistical Package for Social Sciences (SPSS) version 17. Univariate analysis of data was utilized for easy description of the phenomena investigated.

V. Analysis and Discussion of Results

The Environmental Monitoring Unit of the Corporation gave the noise level in the various Units as shown in Table 1. Noise from the refinery encompasses vehicular engine and industrial sound from compressors and pumps (Azubuike, 2010). In the study area, it is pertinent to note that noise level at the Topping Unit is about 80db while it is about 90db at the Power Plant & Utilities and Fluid Catalytic Cracking Units. However, 48.0% of respondents revealed that the noise in the plants occur whenever the plant is running while 52.0% sees noise occurrence as continuous. This phenomenon is not satisfactory as continual exposure to noise no matter the level could lead to deafness. Raymond (2010) opines that at 89 decibels sound is annoying; and that steady exposure to noise in excess of 90 decibels can cause permanent loss of hearing while producing other deleterious effects on human health and on work performance.

Table 1: Noise level in the Corporation

S/N	Location	Noise Level (DbA)	Maximum Allowable Limit (DbA)
1	Reforming Unit	76.1	85-95
2	Topping Unit	83.6	85-95
3	Fluid Catalytic Cracking Unit	84.6	85-95
4	Control Room	61.6	65

Source: Environmental Monitoring Unit Routine Housekeeping Inspection of WRPC, 2011

On industrial vibration, 64.0% of respondents agreed that vibration in the fuel plant comes from machines and equipment constantly running to aid the upgrade of the heavy crude products into lighter products during refining process. About 36.0% of respondents attributed noise and vibrations in the industry to leaking pressure pipes. It is also worrisome to note that there are leaking pipes that have been neglected by the management. Despite all these misdemeanors, operators still work in the Plant without protective equipments.

The respondents were also requested to give their past health records based on the effect of noise and vibrations, and the result of this inquiry is as presented in Fig. 2. The highest percentage (36.0%) of the respondents revealed that noise is the cause of their loss of sleep, while 19.0% confirmed the occurrence of some degree of deafness few hours after industrial operations. About 17.0% constantly experience headaches

from noise and vibrations as 15.0% affirmed that they contribute to the stress diagnosed by medical experts because their body systems respond to the noisy environment. An insignificant percentage (13.0%) of the respondents admitted that noise and vibrations in the factory do not have any health implication on them. However, this phenomenon shows that over 87.0% of the respondents are impaired health-wise due to noise and vibrations.

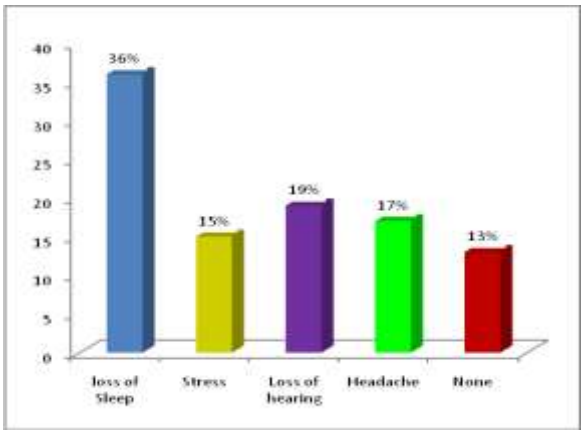

Fig. 2: Effect of Noise and Vibration on Workers' Health Source: Field Survey, 2011

Virtually all the respondents (96.0%) agreed that gas flare occurrence is a daily phenomenon because the fuel plants run continuously. The major form of pollution that occurs during the refining process in the petrochemical industry is gas flaring. A prominent feature in the petrochemical plant is a tall stack with a small flame burning at the top. In most cases, only a pilot light is visible on the flare stack, and steam is often added to the flare to mask the flame. However, during emergency conditions, the flare system disposes of large quantities of volatile gases which illuminate the sky (Solomon, 2010). On normal basis, the primary purpose of the flare is to act as a safety device to protect vessels or pipes from over-pressure due to unplanned upsets. Whenever plant equipment items are over-pressured, the pressure relief valves on the equipment automatically release gases and sometimes liquid (Wikipedia, 2011).

Anele (2010) opines that there are two sources of air pollution in the environment. These include: natural origin such as pollen, fungi spores, salt spray, smoke and dust particles; and Carbon Monoxide (CO), Hydrogen Sulphide (H_2S), Sulphur Oxide (SO_2), and Methane (CH_4) from the anaerobic decomposition of organic matter. The anthropogenic origin include: mobile transport (motor car, trains etc.); stationery combustible (residential, commercial, industrial power and heating); industrial processes (chemical, metallurgical, pulp/paper, petroleum refining); and solid waste disposal (household/commercial refuse, coal refuse, agricultural burning). The effects of constant flaring in the community included thermal heating of the environment, sickness of all forms, stunted growth of plants and consequent lack of adequate food supply and acid rain among others.

VI. Recommendations

One of the general means by which government could control pollution is through regulations that stipulate the maximum allowable emissions or effluent levels (Fatunmobi, 2003). Performance standards are usually set on paper, but monitoring and enforcement in Nigeria have generally been weak. The Federal Government has stipulated laws and decrees to end gas flaring in the country. For instance, the government promulgated the Association Gas Reduction Decree in 1979 which required oil companies to stop any form of flaring by 1984. This decree was later amended in 1985 by fixing 20 kobo penalty for each cubic feet of gas flared. Also, in 2005, the Federal High Court of Nigeria gave a ruling forbidding flaring which was later backed up by an enabling law in 2008 giving January 2008 as deadline for gas flaring. However despite all the court rulings, laws and decrees, gas flaring is a common occurrence in most oil companies in the Niger Delta region.
The Federal Environmental Protection Agency (FEPA) and the Department of Petroleum Resources (DPR), need to ensure that oil companies conform to laid down standards of environmental protection. The following recommendations therefore, should be considered by the relevant government agencies to resolve the issues of environmental pollution and its consequent effects on the host community of the WRPC.

First, DPR as a government agency should be responsive to activities of oil companies by carrying out a regular and constant inspection and monitoring of noise level in the plants in order to ensure that the monthly report of environmentalists in the refinery is correct. The DPR should be prompt at executing sanction on erring companies in this regard.

Second, the FEPA should ensure the adoption of latest technologies in curtailing gas flaring by the refineries. For instance, the Transvac Flare Gas Recovery System which is used to compress low pressure waste gas into the production process. A 1.2 MW Power Generation Unit could be used to generate power from the gas flare for use by the community as an alternative power source to the irregular supply by the Power Holding Company of Nigeria.

Third, the pollution control unit of the agency should make use of the FLIR A320 – an instrument for detecting the amount of CO_2 escaping into the atmosphere during gas flaring process. This instrument also monitors flare stack and pilot flames to meet plant safety and environmental requirements. The system also detects black smoke and provides alarm functions through its web-based connectivity.

It is evident that environmental pollution is a necessary process in all refineries (chemical and natural gas plants). It leads to addition of harmful substances to the atmosphere resulting in damage to the environment, human health, and quality of life. Some air pollutants return to Earth in the form of acid rain and snow, which corrode statues and buildings, damage crops and forests, and make lakes and streams unsuitable for fish and other plant and animal life (Hart, 2009). The location of Ubeji community is less than 1kilometre to the refinery; hence a relocation of the community is inevitable with the passage of time.

VII. Conclusion

Flaring and venting of natural gas is a significant source of green house gas emissions. The release of CO_2 and other poisonous gases into the atmosphere causes unnatural heating effect on the earth's surface leading to global warming. As the world's temperature rises due to the accumulation of greenhouse gases as being witnessed in the Warri refinery, we expect rise in sea level, floods, loss of natural resources and freak weather conditions in the study area. It is hoped that through this project the public would be aware of the various effects plant operations have on the environment. The plant operators would also benefit from it because they are the ones working under such hazardous conditions.

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