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Waste Minimization Strategies and Resource Recovery in Rivers State, Nigeria. Case Study: Indorama Eleme Petrochemical Port-Harcourt.

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ABSTRACT: This study aims to assess the applicability of waste minimization strategies and resource recovery in Indorama Eleme Petrochemical. To carry out this study, three objectives were set, the population for the study was the number of local staffs of the company which was 600. Out of this population, a total of 240 respondents were determined to be the sample size using Taro Yamane formula. The selective sampling technique was employed to draw the sample from the population. The findings of the study indicated that the company generates solid, liquid and gaseous wastes during operational activities; that the company uses the 4R (reduce, reuse, recycle and recovery) to minimize the waste and the daily waste water treatment is efficient.
Recommendations were made for more effective waste minimisation process;more awareness of the minimisation methodsshould be made to employees at each plant unit and proper production planning and control should be strengthened inside the organization.

KEYWORD: Waste Minimization, Resource Recovery, Rivers State, Wastewater, solid waste, Indorama Eleme Petrochemical

I. INTRODUCTION

Waste minimization is one of the most important aspects of integrated waste management. Numerous strategies can be implemented to reduce or minimize waste generation. Waste minimization, or source reduction, refers to the collective strategies of design and fabrication of products or services that minimize the amount of generated waste and/or reduce the toxicity of the resultant waste. Engaging stakeholders in the implementation of zero waste is also aimed at developing a holistic approach to reducing the pollutants effect within and around an organization [1].

The attainment of sustainable development requires a clear understanding by everyone affected, the causes and effects of environmental degradation and measures for redemption or protection. A meta-analysis on the effectiveness of intervention strategies to promote recycling behavior found that informational strategies can promote recycling behavior ([2].

In Rivers State, the uncontrolled emission of methane, which is produced as a by-product of the decomposition of organic wastes, represents a significant proportion of the region's contribution to the greenhouse effect. The increase in potentially hazardous industrial, biomedical and nuclear wastes has not been accompanied by a commensurate expansion in the provision of waste treatment and management facilities. Plastic pollution is a serious challenge, accounting for more than 30 percent of the solid waste generated annually [3].

Indorama Eleme Petrochemical Plant located in the oil rich Rivers State, Nigeria, generates large quantities of effluents daily. The petrochemical plantis designed to produce 360 KT of Poly Ethylene (PE) and 120 KT of Poly Propylene (PP) per year. PE is produced under two major categories High Density Poly Ethylene (HDPE) and Liner Low Density Poly Ethylene (LLDPE). PP is produced under three major categories - Homo Polymer, Random Polymer and

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Co Polymer; and if not managed properly will lead to waste accumulation. Petrochemical plants generate solid waste and sludges, some of which may be considered hazardous because of the presence of toxic organics and heavy metals.

Furthermore, improper management of waste during operational activities brings adverse environmental impact like air pollution, due to the release of hazardous hydrocarbons into that atmosphere, water pollution and soil contamination. Accidental discharges as a result of abnormal operation, especially from polyethylene and ethylene oxide-glycol plants in a petrochemical complex, can be a major environmental hazard, releasing large quantities of pollutants and products into the environment. Wind shift brings diverse odours that offend residents living close to the dump. Burning the garbage causes black smoke, filled with toxic by-products from burning rubber and plastic resulting in change in the air quality, which in future affects human health and well-being causing various diseases such as bacillary dysentery, diarrhea, amoebic dysentery, plague, salmonellosis, trichinosis, endemic typhus, cholera, jaundice, hepatitis, gastro enteric diseases, typhoid, malaria etc. Flood-endangered areas can harm people if the wastewater is not treated [4].Diseases such as asthma, birth defects, cancer, cardiovascular diseases, childhood cancer, low birth weight, and preterm delivery is associated with this effect can also be experienced. This research assesses the applicability of waste minimization strategies and resource recovery in Indorama Eleme Petrochemical Plant by identifying the nature of waste generated, examining the sustainable waste minimization practices adopted by the company and the daily waste water treatment checks.

II. WASTE MINIMIZATION STRATEGIES

Minimizing the quantities of waste requiring disposal, through source reduction, material recoveryand reuse and recycling, is increasingly being realized as the central basis of an integrated approach to waste management. In order to handle the ever-growing volume of wastes, the proper investments need to be made and implemented. The general approach to tackling the problems of waste management in the study area has always been to invest blindly money and equipment with little or no analysis as to their main causes. In recent time, however, there is the general consensus that proper management of waste, which is more compactable with an environmentally sustainable development, should be adopted. Therefore, a sustainable society should not generate waste which exceeds the capacity to manage [5].

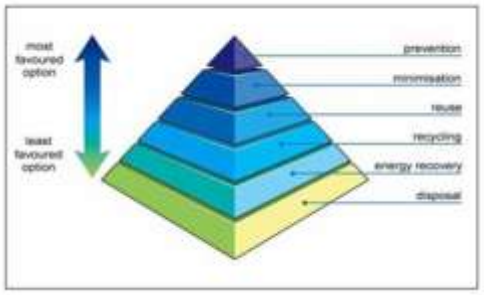

Figure 1: Sustainable Waste Management Hierarchy

Source: [8]

(a) Prevention of Waste Accumulation

This approach is unique because it prevents huge generation of solid wastes and provides for resource conservation. It is also more economical, environmentally safe and legally sound. It is on the highest level in the hierarchy and the ultimate challenge to zero waste. Waste prevention is most effective in a product life cycle, especially during the product design and production process. The waste management hierarchy shows that the best way of managing waste is through prevention because it cuts down the waste management cost [6].

(b) Minimization

Waste minimization is a process of reducing the amount and activity of waste materials to a level as low as reasonably achievable. It consists of reducing waste generation as well as recycling, reuse and treatment, with due consideration for both primary wastes from the original nuclear cycle and secondary wastes generated by reprocessing and clean-up operations. This system will be also useful for reducing the usage of virgin material. [7].

(c) Reuse of Material

Reuse allows the materials to be used again instead of being disposed of in the disposal system. A lot of items can be reused without any processing done to them. Reuse requires less energy than recycling by designing out waste before it is created. This concept is the most dominant concept in the waste management hierarchy because for further usage of a product, new or additional resources are not needed. Reuse does not involve changing the item. For example, typical reuse methods are the deposit refund scheme for glass bottles or polyethylene terephthalate (PET) water bottles, steel drums that are used as compost bins, old tires that

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are used in fences or as boat fenders, plastic bags that are used as liners for household waste bins [8].

(d) Recycling of Waste

Recycling refers to recovery of useful materials such as glass, paper, plastics, wood, and metals from the waste stream so they may be incorporated into the fabrication of new products. With greater incorporation of recycled materials, the required use of raw materials for identical applications is reduced. Recycling reduces the need of natural resource exploitation for raw materials, but it also allows waste materials to be recovered and utilized as valuable resource materials. The importance of visible and accessible recycling centres as well as financial incentives to encourage participation in recycling is supported by many studies as an effective measure in improving waste management strategies [9].

(e) Energy Recovery

Energy recovery is a process whereby some form of waste is generated to form fuel and energy. The importance of energy recovery in contemporary waste management practices remains assured due to its impact on global waste minimization, resource optimization and alternative energy generation [10]. Incineration and pyrolysis are the thermal processes while anaerobic digestion, closed composting and open composting are the biological processes.

(f) Disposal

Disposal is the least sustainable in the waste management hierarchy. Disposal options depend largely on the waste characteristics and regulatory requirements [11]. For most developing countries waste is disposed of on dumpsites and landfills, unlike the developed countries that are moving towards resource recovery. Some types of waste are not easy to reuse and recycle suchas hazardous waste; therefore, the last priority is disposal.

III. MATERIALS AND METHODS

Study area: the study was conducted in Indorama ElemePetrochemical company based in Port Harcourt. Port Harcourt is a large city and the capital of Rivers State, Nigeria. The city is situated in the southernmost part of the country, in the delta of the Niger River. Port Harcourt is a relatively young city established only about 100 years ago.

Figure 3.1: Indorama Eleme Petrochemical Company

Study Population**:** The target population of this study is based on the number of local staff which is 600.

Sample Size Determination: This sample size was determine using Taro Yamane Statistical formula. The study sample size of 240 was obtained.

$$n = \frac{N}{1 + N(e)^2}$$

Sampling Technique: The sampling technique usedwas a selective sampling technique. In this case, only people who are involved at the selected plant unit will be included in the study. The waste management officers, the human resource officer, environmental and safety officer, cleaners, drivers, security personnel. the effluent treatment plant supervisor, and sludge management team will be selected as participants because they have experience and knowledge concerning the problem under the study.

Sources of Data: The study used both primary and secondary sources of data collection. For primary data, interview guides, observation and questionnaires were used. This data was obtained from informants from the selected organization. The secondary data comprised of journal papers, text books Using databases such as; Web of Science, Research gate and Google Scholar. Primary data will be use together with secondary data for the enhancement of data validity and reliability.

Method of Data Collection: Data was collected using the questionnaire, from the selected plants in the company: the olefins plant, the fertilizer plant, the polyethylene, polypropylene plants and effluent treatment plant. A total of 240 copies of the questionnaire were administered to the respondents in their respective unit, using the purposive sampling technique. A face-to-face administration was done by the researcher. All completed instruments were retrieved and analyzed.

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Method of Data Analysis: Data were grouped based on the questions in the questionnaire and checkedfor errors, necessary corrections were made beforethe data analysis. The data were analyzed using frequency distribution table, charts and simple percentage.

IV. RESULTS AND DISCUSSION

Two hundred and forty copies of questionnaires were distributed but only two hundred copies wereretrieved and analyzed giving a response rate of 83.3%.

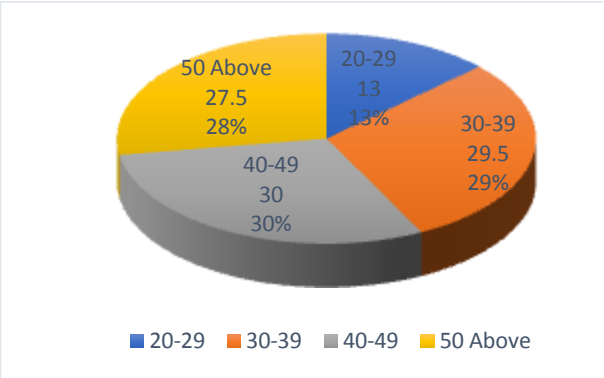

Figure 2: Age Distribution of Respondents

Figure 2 shows the age distribution of the respondents, that the majority of the respondent are between the age of 40-49(30%).

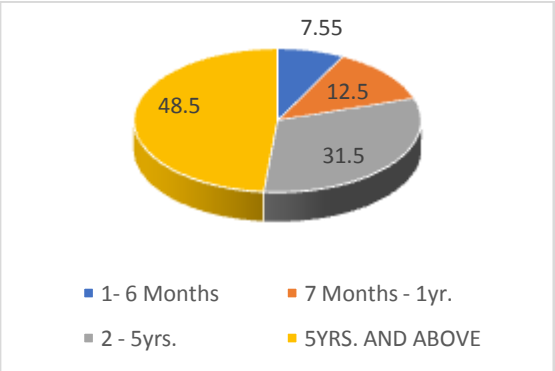

Figure 3: Service Year of Respondents

Figure 3 show that 48.5% persons have worked inthe industry for 5yrs and above.

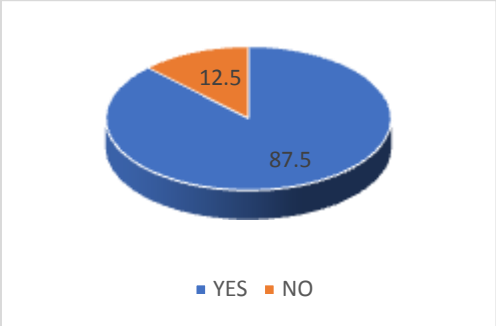

Figure 4: Knowledge about Waste Management

Figure 4 show that majority of the respondent were aware of waste management, about 87.5% (175).

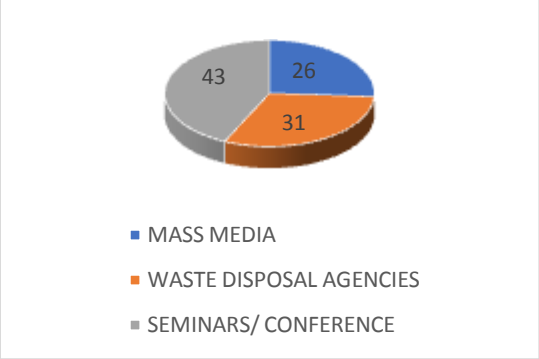

Figure 5: Source of Awareness

Figure 5 depicts that seminarwas the commonest source of information channel. 43% (75) on waste management, then waste disposal agencies 31% (55).Mass media (TV. Radio,newspaper) recorded the least common means 3.9% (11).

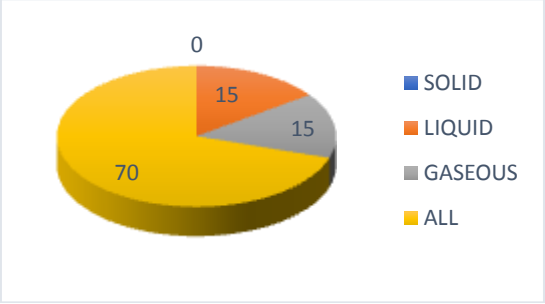

Figure 6: Nature of Waste Generated

Figure 6 indicates that more than half of the respondents agreed that the all the type of waste listed above are being generated.

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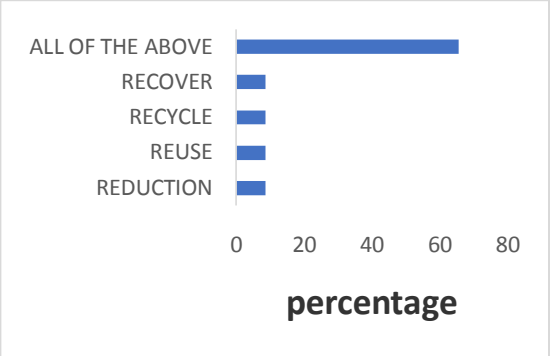

Figure 7: Indorama's Minimization Strategies

Figure 7 indicates that the company uses the 4R (Reduction, Reuse, Recycle and Recovery) to minimize the generated waste.

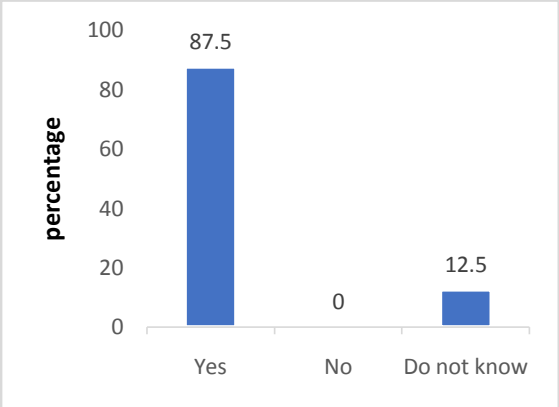

Figure 8: Wastewater Quality

Figure 8 shows that most of the respondents represented by 87.5% agreed that the daily waste water treatment is efficient.

Table 1:Result of Effluent inComparison with NESREA

Parameter	Unit	Effluent	NESREA Standards
BOD5	mg/l	10	30-50
OIL AND GREASE	mg/l	<5	10
PH	Unit	6.0	6-9
TEMP	^{o}C	22.30	40
COD	mg/l	45	60
TSS	mg/l	10	25

Nature of Waste Generated

The study show that the company generates three major types of waste which are solid waste, liquid waste and gaseous waste and this waste are generated from the petrochemical plant process. The solid waste which is generated at terminals include tank bottom sludge which must be removed periodically to maintain product quality and tank storage capacity. The liquid wastes are generated from the boiler blow downs, air compressor intercoolers, turbine condensates, steam condensates, process condensate, and oily effluent from the various processing units and plants. and the gaseous waste which includesemissions from the plant are nitrogen oxides, carbon monoxide, Sulphur oxides, fumes and inert gases**.**

The implication of the above findings' rests in the fact that the waste being generated from the plant are considered hazardous because of the presence of toxic organics and heavy metal. According to [12].A major challenge throughout the oil and gas sector is that many waste streams can become contaminated by oily or hazardous fluids, and radioactivity requiring careful handling, treatment and disposal. as well as spill clean-up materials and soils contaminated with oil.

Sustainable Waste Minimization Strategies Adopted by the Company

The study also reveal that the company uses the 4R. this is supported by the total number of respondents 115 respondents representing 65.6%. Indorama utilizes the 4R (Reduce, Reuse, Recycle and Recover) as a basic principle of its waste management policy. Incinerators at site are used for incineration of inenarrable wastes, waste segregation units where solid waste are segregated into properly labeled receptacles according to the types of waste from where it will be collected for final disposal.

Gaseous wastes are minimized during the plant process operation. The waste streams are sent to the effluent treatment plant in their individual basin where it passes through a treatment process. There is a dedicated scrap yard where a large volume of waste is temporarily kept before reuse, recycling or disposal. Waste manifest, waste tracking, waste quality assessment before final disposal are the quality control measures that are used. Which shows that the company encourages waste management.

Daily Waste Water Treatment Check

Analysis from figure 8 revel that the waste water is efficient enough to be discharged. This is supported by a total of 175 respondents representing 87.5% of the respondents. Effluent streams comprising sewage, process waste water, and blow down are collected into dedicated basins and pumped via pipelines to respective treatment units where it undergoes processes such as hydrolysis, stripping, neutralization, demineralization, and equalization. The quality assessment of treated effluent is assured at the Effluent Treatment Plant (ETP) before final disposal. From the above table wastewater samples show great compliance to the required regulatory limits and therefore safe for disposal.

V. CONCLUSION

The existing waste management strategy in Indorama complex includes waste reduction, waste reuse, waste recycling, resource and final disposal by an accredited waste management vendor. This strategy emphasizes on prevention of waste, followed by reduction, reuse before recycling, recovery and lastly disposal to an approved dumpsite. The philosophy behind this 4Rs is to cut down waste generation to a manageable volume for final disposal. This is in line with the study carried out by [13] and [14] stating that waste management systems have to include reuse and recycling practices, as well as waste reduction policies. Companies should also opt for alternative disposal technologies, in other to reduce the waste disposal in landfills. Hence the need to change people's attitude.However, the following are recommended:

I. Proper production planning and control should be strengthened inside the organization.
II. The government should issue license for effective waste minimization.
III. There should be a proper training and awareness of waste minimization to the employees which include the cleaners, drivers and security personnel at each plant unit.

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