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USE OF INDUSTRIAL POLLUTION PROJECTION SYSTEM (IPPS) TO ESTIMATE POLLUTION LOAD BY SECTOR IN TWO INDUSTRIAL ESTATES IN OGUN STATE, WESTERN NIGERIA

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ABSTRACT

We have used industrial projection pollution system (IPPS) to generate estimates of pollution load by industrial establishments in two industrial estates in Ogun state, Western Nigeria using employment data.

Results indicate that the most polluting sectors are chemical and pharmaceuticals (CPH), basic metal (BML) and food, beverage and tobacco (FBT), the three giving a cumulative contribution of 97.18% of pollution to all media. The least polluting sectors are Electrical and electronic sector (EES) (0.02%), Motor vehicle assembly (MVA) (0.04%) and Wood and wood products (WWP) (0.13%). The trend is consistent with results obtained in other developing economies although estimation parameters differ. They sectoral ranking of pollution intensity is similar to the findings of Oketola and Osibanjo[10, 12] in a similar study for Lagos.

It has been established that few sectors account for most pollution load to the environment. They are also the sectors that account for 83.36% of the total personnel employed. There is thus a need to formulate policy that would reduce pollution load without significantly reducing employment.

KEYWORDS: Industrial Pollution Projection System (IPPS), Pollution Intensity, Pollution load, Industrial Pollution, Employment.

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INTRODUCTION

The quest for industrial development is one of the main objectives of nations. Industrial production, however, comes with attendant problems especially that of pollution. Governments and, at times, private establishments use the establishment of industrial estates as incentives for entrepreneurs to start manufacturing projects in specific areas known as Industrial Estates. Government's intention is generally to stimulate the creation of multiplier effects from such industries for its citizens and also earn itself extra revenue in form of taxes.

Ota industrial estate was established to lure manufacturing industries from the older and, then increasingly chocked, Ikeja industrial estate by the Ogun state Government to facilitate rapid development of the area. The seeming lack of adequate space, planning and proper management led to the start-up of another industrial estate at Agbara by a private concern. The latter introduced centralized waste management systems to ensure efficiency. However, all industries in the estates generate industrial pollution load whose effects on the environment could not be properly assessed as they could not be quantified. Plant level monitoring of air, water and toxic emissions are virtually non-existent and the lack of trained personnel make pollution load associated with these processes virtually impossible to evaluate. This ultimately makes developing countries, unlike their developed counterparts, unable to get required information to set priorities, strategies and action plans on environmental issues. The World Bank team developed the Industrial Pollution Projection System (IPPS) as a rapid assessment tool for pollution load estimation for policy development.

The Industrial Pollution Projection system (IPPS) is a modelling system using industry data to estimate industrial pollution profiles for countries, regions, urban areas and even proposed projects. IPPS has been developed to exploit the fact that industrial pollution is heavily affected by the scale of industrial activity, its sectoral composition, and the process technologies employed in production. Although most developing countries have little or no industrial pollution data, many of them have relatively detailed industry survey information on employment, value added or output. IPPS is designed to convert this information to the best feasible profile of the associated pollutant output for countries, regions, urban areas or proposed new projects. It operates through sector estimates of pollution intensity, or pollution per unit of activity. IPPS is based on a combination of data of industrial activity (like production or employment) with data on pollution emissions to obtain pollution intensities (which is defined as pollution per unit of output or pollution per unit of employment) [7] with respect to any of three economic variables – total output, value added and employment.

IPPS was developed from a database of environmental and economic data for about 200,000 facilities spanning 1500 product categories with different operating technologies and pollutants to project air, water and solid waste emissions. It incorporates a range of risk factors for human toxic and ecotoxic effects. Although, undoubtedly the most comprehensive system of its kind in the world, the applicability of IPPS to other economies will normally be influenced by many country-specific factors hence values obtained serve as a guide to probable pollution problems.

This study estimates the pollution load to all media of industries in the two industrial estates located in Ogun state, Western Nigeria

using IPPS values with respect to employment based on the four-digit levels of aggregation in the International Standard Industrial Classification (ISIC). Thirty seven (37) manufacturing concerns were divided into the sectoral groups and IPPS used to estimate pollution intensities into the various selected media.

2. EXPERIMENTAL: MATERIALS AND METHODS

2.1 Description of study area

The close proximity (figure 1) to the commercial capital of Nigeria – Lagos obviously influenced the location of the two industrial estates in adjoining Ogun state, Western Nigeria. Ota Industrial Estate was established by the Ogun state government in 1983 to attract some manufacturing concerns out of Lagos and also provide additional revenue sources to the state. The Agbara Industrial Estate, though a private initiative, was established with similar objectives in mind. This closeness to Lagos is to encourage industrial premises in Lagos to relocate to supposedly better planned systems with some financial benefits like tax exemptions thrown in.
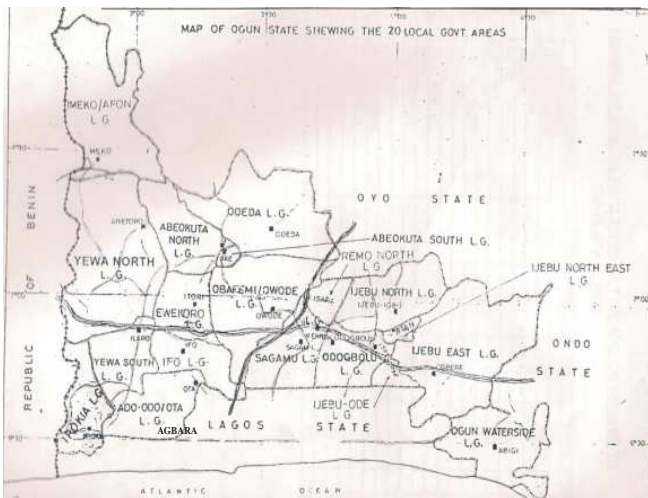

Figure 1: Map of Ogun State, Nigeria showing the location of OTA and AGBARA Industrial estates

2.2 Data acquisition

Lower bound (LB) pollution intensities by media with respect to employment obtained from the World Bank report[7, 8] was used to calculate the pollution load for 9 industrial sectors obtained after merging the intensities of the 79 major categories in the ISIC code. Employment data covering the 4-year period of study (2005 – 2008) were obtained from the Manufacturers' Association of Nigeria (MAN) and, where insufficient, from the individual companies.

Aggregated pollution intensities were estimated using the formula:

$$PL = \frac{PI \times TEM}{1000 \times 2204.6}$$

Where PL= pollution load in ton/y

TEM = total number of employees

PI = pollution intensity in pounds per thousand employees per year

2204.6 is the conversion factor from pounds to tons

2.3 Statistical analysis

A 2-tailed Pearson correlation and Analysis of Variance (ANOVA) were used to test the data obtained. The results indicate close correlation within sectors but across sectors, the correlation is doubtful.

3. RESULTS AND DISCUSSION

Table 1 shows the contributions of each sector to air pollution load (ton/yr) with respect to employment in the Industrial estates. Basic Metal sector (BML) has the highest number of employees during the period of study followed by Chemicals and Pharmaceuticals (CPH), Food, Beverage and Tobacco (FBT), Domestic and Industrial Plastics (DIP) and Wood and Wood Products (WWP) respectively. Paper and Pulp products (PPP), Electrical and Electronic sector (EES) and Non-metallic Mineral Products (NMP) have the least number of employees.

Sector	No. of Employees	Sulphur dioxide (SO_2)	Nitrogen dioxide (NO_2)	Carbon monoxide (CO)	Volatile Organic Carbon	Fine particulate matter	Total suspended particles
FBT	1220	5989.22	3358.46	959.42	4025.67	2013.52	4312.1
WWP	204	30.01	36.68	32.09	96.04	12.60	55.36
PPP	46	132.39	71.54	147.44	24.10	7.30	27.45
CPH	2016	29301.8	17697.30	24240.70	14245.50	355.42	4958.9
NMP	9	111.67	63.59	9.73	2.03	93.91	63.28
DIP	827	517.69	1412.58	206.98	1244.49	4.16	141.77
EES	35	8.19	2.76	4.89	5.04	0.03	0.63
BML	2236	11526.9	2438.20	9130.85	2246.45	907.63	1710.7
MVA	92	5.11	2.89	3.41	62.21	0.14	2.54

Table 1: Sectoral Air pollution load.

3.1 <u>Air Pollution Load</u>

3.1.1 Air pollution load distribution by pollutant type

Emission into air was estimated based on emission of Total Suspended Particulates (TSP), Sulphur (IV) oxide (SO_2), Nitrogen (IV) oxide (NO_2), Carbon monoxide (CO), Fine particulates (FP) and Volatile organic carbon (VOC). The values obtained are given in Table 1. Chemical and Pharmaceutical (CPH) sector is the highest generator of emissions for 5 of the 6 USEPA's criteria air pollutants accounting for 61.53% (SO_2), 70.55% (NO_2), 69.79% (CO), 64.9% (VOC) and 63.19% (TSP). BML is the next serious polluting sector with 24.20%, 9.72%, 26.29%, 10.23% and 23.75% respectively. The least polluting sector is the non-metallic products (NMP) with 0.23%, 0.25%, 0.03%, 0.01% and 0.78% for the pollutant types. The wide variety of chemical entities utilized in both CPH and BML sectors would account for their relative high mix of pollutants. FBT, in the emission of FP with 59.31%, is the exception to this general rule.

3.1.2 <u>Air pollution load distribution by sector</u>

Air pollution load is mainly from the CPH – 90799.65 ton/yr (63.03%), BML – 27960.7 ton/yr (19.41%) and FBT – 20658.44 ton/yr (14.34%) sectors contributing a cumulative load of 96.78% of total air pollution into the air. The least polluters are MVA – 76.3 ton/yr (0.05%) and EES – 21.54 ton/yr (0.01%). The relative contribution values are given in figure 2.
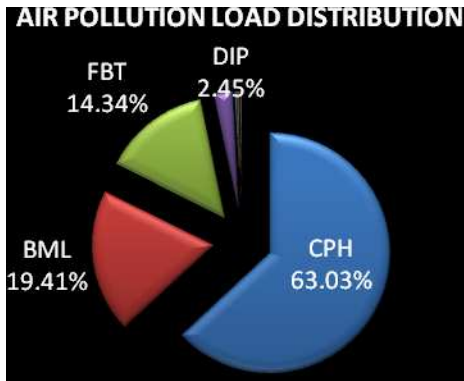

Figure 2: Relative contribution to Air pollution by sector

3.2 <u>Water pollution load</u>

This was estimated relative to the chemical measurement terms Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS) – the two US EPA's water pollutant indicators and the values obtained are shown in Table 2.

Sector	No. of Employees	Biological oxygen Demand (BOD)	Total suspended solids (TSS)
FBT	1220	3065.53	2997.66
WWP	204	1.05	4.89
PPP	46	70.01	235.28
CPH	2016	1443.95	9024.44
NMP	9	0.03	2.21
DIP	827	41.51	168.91
EES	35	0.65	0.95
BML	2236	590.13	42921.50
MVA	92	0.03	0.22

Table 2: Sectoral pollution Load to Water

By far the highest sector for pollution into water is BML – 43511.59 ton/yr (71.84%) followed by CPH – 10468.4 ton/yr (17.28%) and FBT – 6063 ton/yr (10.01%). The three give a cumulative load of 99.13% of total pollution load to water. Industries in these sectors are liable to washings between lots/batches and have a high tendency to use water as a medium for these processes. This would account for the high TSS values for BML -42921.45ton/yr (77.54%) and BOD values for FBT- 3065.53 ton/yr (58.81%). CPH – (16.3% TSS, 27.7% BOD) comes in between in both cases. All other sectors have negligible contributions as shown in figure 3.
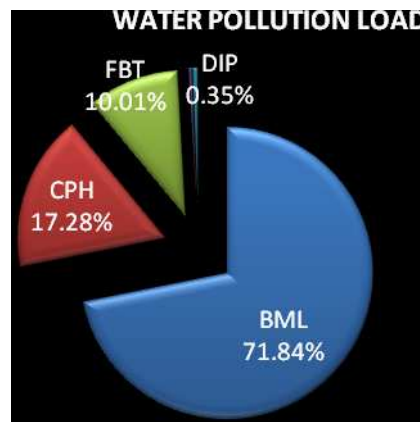

Figure 3 Relative contributions to water pollution by sector

3.3 Toxic chemical pollution load

The most likely causes of chemical pollution are residues of pesticides, organic chemicals like benzene, toluene, xylene, chloroethane and chloromethane[7, 8]

3.3.1 Toxic chemical pollution load distribution by medium

Toxic chemical pollution load was estimated into 3 media – air, water and land and the pollution intensities are given in Table 3.

Sector	No. of Employees	Toxic chemical to Air (TCA)	Toxic chemical to Water (TCWAT)	Toxic chemical to Land (TCLAND)
FBT	1220	195.58	35.99	467.41
WWP	204	20.19	0.02	2.37
PPP	46	25.26	6.10	10.08
CPH	2016	4619.83	992	12349.70
NMP	9	0.78	0.05	0.82
DIP	827	700.27	41.54	523.90
EES	35	2.99	0.03	3.17
BML	2236	1736.33	98.61	3115.08
MVA	92	9.35	0.64	4.85

Table 3: Sectoral Toxic Chemical pollution load.

The major toxic chemical polluters to air are CPH - 4619.83 ton/yr (63.19%) and BML – 1736.33 ton/yr (23.75%) while PPP – 25.26 ton/yr (0.036%) and NMP – 0.78 ton/yr (0.04%) are the least contributors.

CPH – 992.01 ton/yr (84.43%) is the main polluter to water while EES – 0.03 ton/yr and NMP – 0.05 ton/yr are negligible contributors. Toxic chemical pollution to land is contributed mostly by CPH – 12349.69 ton/yr (74.95%) followed by BML – 3115.08 (18.91%). Conversely, WWP- 2.37 ton/yr (0.01%) and NMP – 0.82 ton/yr are negligible contributors. The results could be attributed to the high chemical usage in CPH and BML industries.

3.3.2 Toxic chemical pollution load distribution by sector

CPH gives the highest emission of toxic chemicals to all media with a total intensity of 17961.53 ton/yr (71.95%). The sector is followed by BML (19.83%), DIP (5.07%) and FBT (2.80%) as the major contributors to toxic chemical pollution load. The least toxic chemicals polluting sectors are MVA (0.06%), EES (0.02%) and NMP (0.01%). The relative contributions of each sector are shown in figure 4.
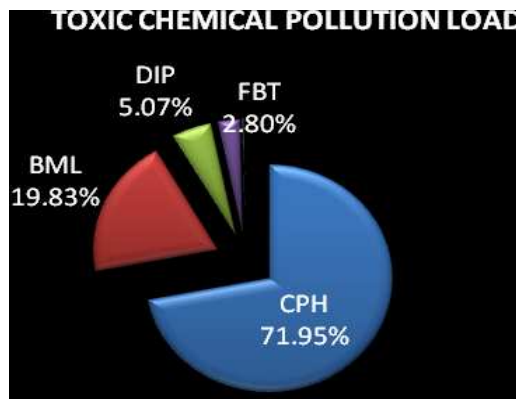

Figure 4: Relative contribution to toxic chemical pollution to all media

3.4 Toxic metal pollution load

Hettige et al[7] listed metal compounds used in the estimation of toxic metal intensity as Al, V, Zn, Sb, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Hg, Ni, Ag and their compounds, thallium, thorium dioxide and titanium tetrachloride.

3.4.1 Toxic metal pollution load distribution by medium

Toxic metal pollution load estimates for all sectors is given in Table 4. BML is the largest polluting sector for toxic metals with 82.36 ton/yr (76.96%), 2045.39 ton/yr (82.84%) and 5.53 ton/yr (31.37%) to air, land and water respectively. It is surpassed in intensity of pollution to water by CPH with 11.46 ton/yr PI (65.02%). All other sectors contribute negligibly to contamination to this medium.

Sector	No. of Employees	Toxic Metal to Air (TM Air)	Toxic Metal to Land (TM Land)	Toxic Metal to Water (TM Water)
FBT	1220	0.19	0.06	0.05
WWP	204	0.03	0.32	0.00
PPP	46	0.04	0.09	0.04
CPH	2016	23.40	367.47	11.46
NMP	9	0.02	0.12	0.00
DIP	827	0.60	46.97	0.54
EES	35	0.33	8.12	0.01
BML	2236	82.36	2045.40	5.53
MVA	92	0.05	0.64	0.00

Table 4: Sectoral Toxic Metal pollution load.

3.4.2 Toxic metal pollution load by sector

Toxic metal pollution load estimates show that BML is the highest polluting sector with 2133.27 ton/yr (82.24%). CPH with a pollution load of 402.32ton/yr (15.51%) and DIP with a load of 48.22 ton/yr (1.85%) make these three sectors have a cumulative pollution contribution of 99.6% emphasizing the fact the toxic metal pollution of all the other sectors are insignificant. These facts are presented in figure 5.
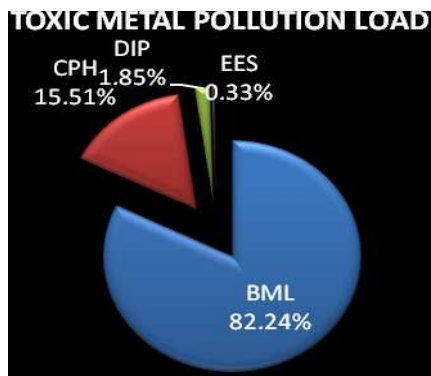

Figure 5: Toxic metal pollution load by sector

3.5 Total pollution load to all media by sector

Sectors	$PL_{(air)}$	$PL_{(TC)}$	$PL_{(TM)}$	$PL_{(W)}$	TPL	% Contribution
FBT	20658.44	698.97	0.30384	6063.195	27420.91	11.81
WWP	262.79	22.58	0.34664	5.937907	291.6536	0.13
PPP	410.22	41.44	0.164123	305.2986	757.1199	0.33
CPH	90799.65	17961.53	402.3281	10468.4	119631.9	51.52
NMP	344.20	1.65	0.144812	2.237863	348.2343	0.15
DIP	3527.68	1265.71	0.144812	210.4198	5051.91	2.18
EES	21.53	6.19	8.46198	1.60077	37.78803	0.02
BML	27960.7	4950.02	2133.273	43511.59	78555.58	33.84
MVA	76.29	14.83	0.691783	0.255809	92.0722	0.04

Table 5: Total pollution load to all media by sector

Table 5 shows the pollution load by all sectors to all the studied media and their percentage contributions to total pollution load to the environment. CPH is the most polluting sector with a total pollution load of 119631.9 ton/yr or 51.52% of the emissions of the studied pollutants followed by BML with a total contribution of 33.83% (78555.58 ton/yr). The next highest polluting sector is FBT

with a total pollution load of 27420.91 ton/yr (11.81%) and DIP with a contribution of 5051.91 ton/yr (2.18%). All the other sectors contribute negligibly to pollution load and this is amply demonstrated in figure 6.
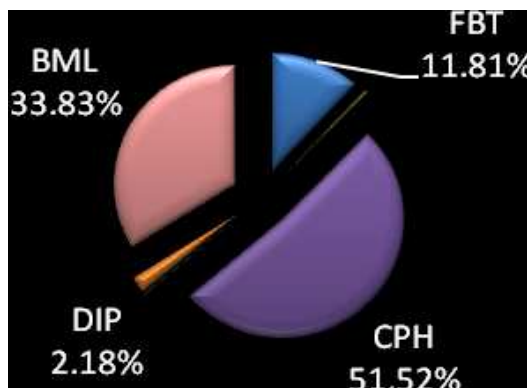

Figure 6: Total Pollution load to all media by sector

3.6 IPPS, Its Applications in other climes

This study is a continuation of the World Bank objective of compiling cross-country and cross regional variations in economic and sectoral policies as well as strictness of regulation in various regions of the world.

IPPS has been useful in developing policy in developing countries mainly due to its relatively modest data requirements. It can be used as an early warning mechanism designed mainly to identify situations where toxics emitted by manufacturing processes could be a major concern. It is pertinent to mention that EPA data used to calculate IPPS coefficients only cover facilities releasing pollutants over a threshold level of emissions hence PI based on these data may be biased. There is also an underestimation bias in these calculations because the coefficients assume the hypothesis that non-reporting facilities have no emission (hence are assigned zero emission). The results thus obtained can only be indicators of actual emission.

IPPS estimates are not intended as an alternative to proper monitoring of pollution sources but to provide regulatory agencies with information that can help to prioritize the monitoring effort and help in allocating monitoring resources more efficiently[2]. While in the industrializing economies of South America, input-output data is used [2, 5] to estimate the value of production and potential PI using IPPS, in the developing economies like in West Africa, employment is the most reliable indicator of scale of activity hence production levels. The index used for measurement plays a vital role in the pollution load values obtained. The application of IPPS in Latvia[9] and Lagos[11] using both production and employment indices show that estimates of pollution emissions are larger using employment by a factor of approximately 1 to 10 compared to when production indices are used. This could be due to exchange rate factors with variations playing a major role. Overstaffing, especially in developing countries, would also impact on pollution load. Etim[4], in a comparison of two modelling techniques – IPPS and rapid

pollution inventory survey RPIS[3]- using employment indices found that IPPS generally gave higher pollution loads than RPIS. Benoit and Craig[1] found, in Thailand, that although environmental laws and institutions were in place, weak monitoring and enforcement policies were hindering policy formulation. This is generally the situation in developing countries hence the need for modelling techniques like IPPS to formulate policy. Results from such studies could thus be used to recommend appropriate responses to emergent pollution problems especially for new projects. The fact that most industries in the developing economies of the world use older manufacturing technologies would also indicate that PI should be higher than IPPS estimates which are based on relatively newer technologies.

The overall trend in industrial pollution in an expanding economy depends on whether the scale effect of expanding output is counteracted by the process effect and whether or not the composition effect tends to reinforce the scale effect or offset it.

4.0 Conclusion

IPPS is a veritable tool in estimating pollution load in developing countries where sufficient data for mass balance calculations from production processes are not available. This is especially useful in mitigating pollution effects from industry in countries that have no other parameters than employment figures. The results are in agreement with the trend in developing countries of Asia and South America even though the value added index is widely used in those countries due to the availability of export data. The results further reinforce the postulations of the Kuznets curve[6] that relates pollution to level of wealth of an economy and is a further vindication of the apostles of "Pollution havens".

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