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Investigation on the Effect of Aluminium Smelting on Air Quality at Rusal Alscon Ikot Abasi, Akwa Ibom State

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Authors' contributions

This work was carried out in collaboration between all authors. Authors WAA and DKU designed the study, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Authors WAA, DKU and EGI managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This research work addresses the impact of Aluminium smelting on air quality at Ikot Abasi environment arising from the operational activities of Rusal-Alscon plant. The research was conducted by the collection of in situ air quality samples from selected locations close to the plant. Air quality data, 60, km at Ikot Usung Ikono, Uyo from the plant location was used as a control sample. Air quality results showed marked differences in the air quality around the plant, compared to the standard and the control sample. This research therefore recommends adequate monitoring of the plant operations by the Nigerian Environmental Standards and Regulations Enforcement Agency (NESREA) to ensure conformity to its emission standards.

Keywords: Aluminium smelting; emissions; pollutants; air quality; sound; environment.

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1. INTRODUCTION

Aluminium is never found in nature as an element owing to its affinity for oxygen [1]. It is the third largest abundant element in the Earth's crust. Aluminium hydroxide and bauxites are the basic raw material for primary aluminium production. The major bauxite deposits are located in the tropics and Mediterranean regions of the World. Due to its high affinity for oxygen, aluminium cannot be reduced to metal by heating. The production process consists of the electrolytic decomposition of alumina in a molten bath composed of cryolite and fluorides in which the carbon anodes collect the oxygen, released from the decomposition process. The liquid Aluminas deposited on the carbon coating of the crucible (pot) which acts as the cathode. The molten Aluminium is subsequently pumped into crucibles of metal which are taken to the ingot casting area.

The Rusal-Alscon plant gets its raw materials from Republic of Guinea in West Africa. The plant utilizes the Bayer process in its Aluminium production. Two to three tons of bauxite are required to produce one tone of alumina and two tons of alumina are required to produce one tone of Aluminium metal. Alumina is further reduced into Aluminium in Aluminium smelter plant using Hall-Herouth process. There are two primary technologies using the Hall-Herouth process-The Solderberg cell and the Prebake cell. Modern primary Aluminium production facilities use a variant on Pre;bake technology called Centre Worked Pre-bake(CWPB) technology. A key feature of this process is the enclosed nature of the process Emissions from the cells are very low, less than 2% of that generated. The balance of the emission is collected inside the cell itself and carried away to a very efficient scrubbing system which removes particulates and gases [2]. Computer technology controls the process down to the finest detail, which means that occurrence of the anode (–) the production of Perfluorocarbons (PFCs) produced can be minimized. The Aluminium industries have standard practices governing its operations. Emissions from Alumimum smelting is generally categorized under class 3 indicators [3]. It is highly hazardous, carcinogenic, tetratogenic, mutagenic and highly toxic. The pollutants are capable of causing harmful effect to health of the workers, fauna and vegetation and the safety of the community. The concentration if exceeded may affect the health of the population is called primary pattern. Any concentration with minimum adverse effects on the well-being of the population is classified as secondary pattern. The emissions into the atmosphere include sulphur dioxide, carbon dioxide, ozone, nitrogen dioxide, fluorides, polycyclic aromatic hydrocarbons(PAHs), perfluorocarbons (PFCs), hydrogen fluoride-gases, sodium and aluminum fluorides and unused cryolite as particulates unless carefully controlled are very toxic to the vegetation around the plant These particulates eventually get into air, soil and water. Previous research work on the effects of aluminium smelting on the plant site and the environment at Rusal-Alscon are available [4,5] and were limited to the effect of pollutants on soil and water whereas the present study focuses on the effect of the pollutants on air. Other related works are presented in [6,7,8] and [9] respectively. [10] has made a review of the operational status of the Rusal-Alscon with a view of meeting best practices in operations and safety standards. The main objective of the research is to establish the effect of aluminium smelting on the air quality at/near the Rusal Alscon plant at Ikot Abasi. The research is also a fact finding mission to determine whether the smelting operations in the plant conform to international best practice.

2. METHODOLOGY

Direct data were captured in the course of this study. The air quality samples were captured close to plant site at points A, 0.5 km north of the factory site. At point B 4 km South of the factory site, sample was also collected. Similar sample was also collected at point C, 11 km east of factory site and D 12 km north of the factory site. Control samples of air quality were collected from Ikot Usung village about 60 kilometers from the plant site .The air quality samples collected was analyzed. Interviews were conducted with experts and plant operators to draw conclusions with the analyzed data.

3. RESULTS AND DISCUSSION

Table 1 shows the values of air quality samples collected around the plant site. Table 2 similarly shows the air quality result of the control sample at Ikot Usung Village. Table 3 shows the standard and recommended air quality results.

The emitted values of nitrogen dioxide, sulphur dioxide, hydrogen dioxide and carbon monoxide shown in Table 1 are much higher than the

recommended values in Table 3. At point A the amount of nitrogen dioxide recorded is 0.13 ppm while the recommended standard is 0.021 ppm, the lowest recorded at point E is still significantly higher than the standard. More worrisome is the amount of hydrogen sulphide in the range of 0.4 ppm-0.6 ppm around the plant. The recommended emission rate is 0.0797 ppm hydrogen sulphide is very injurious to health and can cause instant death over a long time of exposure. Thus for a plant that is expected to run continuously throughout the year with minimal down time the residents around are thus exposed to danger. The amount of particulate matter (SPM) varies between 1.0 ppm and 3.0 ppm while the standard is 0.022 ppm. The temperature distribution at A 0.5 km from the plant is $30^{o}C$ which is a little higher than the expected ambient temperature is $27^{o}C$ at the time conducting this research. Higher temperature can cause discomfort to humans and may affect some economic trees in the nearest communities. The humidity of 42% is within the recommended standard has shown in Table 3. The sound pressure to the surroundings lies between 54.4 and 73.7 dB. These are much higher than 50 dB recommended for residential areas in Table 3. These results show the severe impact of Aluminium operation with poor or sub-standard emission control on the air around the environment. It is worrisome if these are allowed to continue over the economic life time of the plant.

Table 1. Metrology and air quality result for communities around Rusal Alscon

Data point	Noise (dB)	NO_2 (ppm)	SO_2 (ppm)	H_2S (ppm)	CO (ppm)	NH_3 (ppm)	Cl_2 (ppm)	HCN (ppm)	SPM (ppm)	T $^{\circ}C$	RH
A	54.4	0.13	0.2	0.6	8.8	3.0	0.3	1.0	3.0	30	42
B	69.1	0.12	0.15	0.5	8.0	2.5	0.2	<0.1	2.0	29	40
C	57.3	0.1	0.1	0.4	7.0	2.0	0.2	<0.1	2.0	31	43
D	73.7	0.1	0.1	0.4	7.0	2,0	0.2	<0.1	1,0	30	42
E	61.8	<0.1	<0.1	0.4	7.0	1.0	0.1	<0.1	1.0	32	42

Note: Point A-Close to the proposed Akwa Ibom State Refinery- 0.5 km North of Smelter Plant factory; Point B-Sir Udoma round about- 4 km South of Smelter Plant factory; Point C- Methodist Church Nigeria - 11 km East of Smelter Plant factory; Point D Ette town market 10 km West of Smelter Plant factory; Point E Essene town of Ikpa Nsung Assang- 12 km North of Smelter Plant factory

Table 2. Air quality results around Ikot Usung Village, Ikono Clan, Uyo L.G.A

Data point	Noise (dB)	NO_2 (ppm)	SO_2 (ppm)	H_2S (ppm)	CO (ppm)	NH_3 (ppm)	Cl_2 (ppm)	HCN (ppm)	SPM (ppm)	T $^{\circ}C$	RH	Pressure mmHg
3 km East of Ikot Usung	38	0.1	0.15	0.15	4.0	2.0	0.1	<1.0	0.39	31	34.5	727.5
3 km West of Ikot Usung	40	0.1	0.1	0.1	4.0	2.5	<0.1	<0.1	0.41	31.5	36	728
3 km South of Ikot Usung	43	0.1	0.16	0.16	4.0	2.3	0.1	<0.1	0.37	32	37	729.5

Table 3. Air quality standards by World Health Organization (WHO) and USEPA

SPM_{10} Ppm (p/a)	NO_2 (ppm) (p/a)	SO_2 (ppm) (p/a)	H_2S (ppm) (p/a)	CO (ppm) (p/hr)	NH_3 (ppm)	$Temp.^{o}C$	RH (mm)	Cl_2 ppm	HCN ppm	Noise (dB)
0.022	0.021	0.026	0.0797	20	**NIL**	27-29^{0}C	25%-60%	0.01	1.0	50

Source: [11,12]

The air quality results at Ikot Usung village are better than those at the plant site but fall short of the recommended standards. More worrisome is the quantity of hydrogen sulphide which at 0.1 ppm is still much higher than the maximum of 0.0797 ppm recommended. The high rates of nitrogen dioxide, sulphur dioxide, and carbon dioxide could be attributed to vehicular, petrol and diesel engine operations and human activities, this is also not without diffusion of gases from process plants in the region which Rusal-Alscon is operating. The average value of chlorine 0.2 ppm at both the factory site and neighboring villages is so high quite above the acceptable limit of 0.01 ppm which can be injurious to inhabitants of that environment. Also cyanide has an average value of less than one (< 1.0 ppm) as against a standard value of 1.0 ppm which is within the tolerable limit thus not likely to pose a serious problem to the inhabitants of that environment.

These results show the need of more researches in this direction in order to determine sources of these gases and ways of reducing their emission to the environment. Table 3 presents air quality standard by WHO and USEPA as adopted for discussion in this work.

4. CONCLUSIONS/RECOMMENDATIONS

From this research it is clear that the Rusal-Alscon is not operating within the standards of best practice in the industry as shown on Table 2. The carbon dioxide, carbon monoxide, hydrogen sulphide, nitrogen (iv) oxide, and ammonia emission levels at the plants and its environments are all above the recommended levels for safety. Operational and maintenance audit of the plant is recommended to save human and the environment from its effect. Regular public awareness on the effect of these plant emissions is also necessary.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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