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Automated Air Pollution Control in Nigeria Using Nature Technogenics Approach

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ABSTRACT

The effect of air pollution in the major Industrial areas in Nigeria especially the oil producing states is severe and the government, through the regulating bodies, is doing her best to curtail the emission of these pollutants into our environment. Efforts made by the government both in form of acts, Laws and even incentives has achieved a relatively low output due the human factor hindering their strict implementation. In this study, a review of the work done in the Niger Delta Region of Nigeria on the major air pollutants (Carbon oxides (Cox), Nitrogen Oxides (Nox), Sulphur Oxides (Sox), Ammonia (NH3), Chlorofluorocarbons (CFCs), Volatile organic compounds (VOCs) and the major operations that mostly result in their emission into the atmosphere is discussed and a solution to the major implementation issue (the human factor) has been introduced and recommended. In this paper, the closed loop control system "NATURE-TECHNOGENICS" is analytically introduced which is a system that monitors the toxic emission using mobile sensors for pollutant concentration estimation and controls this emission using a warning and a shutdown control system. The components and working principle of this system is discussed using the most frequent pollutants in gas flaring (COx, Nox and SOx) as reference pollutants. Nature-Technogenics operates in real-time and has a section in the control unit responsible for transmitting information to a display device at all levels of management from sources of pollutants to the decision-makers at the federal level. This system therefore proffers a potential lasting solution to air pollution issues in Nigeria.

Keywords: Metrological Support, Pollutants, Emission, Real Time, automated control, Ecology.

INTRODUCTION

It is an already established fact that air pollution does not only destroy wildlife and have a negative impact on human health, but are also capable of changing the atmospheric properties. This change in atmospheric properties often leads to undesirable environmental and climatic consequences like acid rain and global warming. Respiratory tract diseases and many other related health issues has been found to be on the high side in area of poor

air quality [1] [6]. Therefore, nowadays the issue of reducing pollutants has become extremely important especially for developing and under-developing nations with inadequate health facilities where prevention has become the most effective approach to disease control.

From the time when the oil industry started operation in Nigeria, more than 35 years ago, there has been major concern and effort on the part of the government to restrain flaring of gases as we will see in the subsequent section of this study. However, Nigeria still flare more natural gas associated with oil extraction than any other country resulting in air pollution in the areas where these industries operate. Estimates suggests that of the 3.5 billion cubic feet (100,000,000 m^3) of Associated Gas (AG) produced annually, 2.5 billion cubic feet (70,000,000 m^3), or about 70% is wasted via flaring. This equals about 25% of the UK's total natural gas consumption and is the equivalent to 40% of the entire African continent's gas consumption in 2001. Though Statistical data associated with gas flaring may be notoriously unreliable, Nigeria could be wasting US$ 2. Billion/year by flaring associated gas [2].

Why Flare? - Flaring is mostly done as it is costly to separate commercially viable associated gas from the oil. Companies operating in Nigeria also harvest natural gas for commercial purposes, but prefer to extract it from deposits where it is found in isolation as non-associated gas. Thus associated gas is burned off to decrease costs [3].

What do we lose when we flare and who should Nigeria learn from? - Gas flaring is generally discouraged as it releases toxic components into the atmosphere and contributes to climate change. In Western Europe 99% of associated gas is used or re-injected into the ground. Gas flaring in Nigeria began simultaneously with oil extraction in the 1960s by Shell-BP. Alternatives to flaring are gas re-injection, or to store it for use as an energy source [4]. If properly stored, the gas could also be utilized for community projects. Gas flaring releases large amounts of methane, which has a high global warming potential. The methane is accompanied by the

other major greenhouse gas, carbon dioxide, of which Nigeria was estimated to have emitted more than 34.38 million metric tons of in 2002, accounting for about 50% of all industrial emissions in the country and 30% of the total CO2 emissions. While flaring in the west has been minimized, in Nigeria it has grown proportionally with oil production [5]. The international community, the Nigerian government and the oil corporations seem in agreement that gas flaring needs to be curtailed. Efforts to do so, however, have been limited although flaring has been declared illegal since 1984 under section 3 of the "Associated Gas Reinjection Act" of Nigeria. Despite this Act, a report from World Bank in 2004 claims that, "Nigeria currently flares 75% of the gas it produces" [7]. Gas flares have potentially harmful effects on the health and livelihood of the communities in their vicinity, as they release a variety of poisonous chemicals including nitrogen dioxides, sulphur dioxide, volatile organic compounds like benzene, toluene, xylene and hydrogen sulfide, as well as carcinogens like benzapyrene and dioxin. Humans exposed to such substances can suffer from a variety of respiratory problems. A study done by Climate Justice Estimates that exposure to benzene would result in eight new cases of cancer yearly in Bayelsa State alone [3][4][21]. Many of these communities claim flares in close proximity cause acid rain which corrodes their homes and other local structures, many of which have zinc-based roofing. Some people resort to the use of asbestos-based material, which more effectively repel acid rain deterioration.

High level of Corruption is one of the major attributes of any developing countries [8] and this study is geared towards reducing the effect of corruption in pollution control. Despite the measures put in place to control some of the major sources of air pollution, Nigeria is yet to boast of good air quality, mostly due to poor implementation of these control measures owing to the human factor and some other factors [9]. A summary of the major factors preventing better air quality in Nigeria will include:

· Lack of emissions inventory/database due to lack of consistent and systematic measurements.
· Unavailability of air pollution and GHG monitoring systems in the Niger Delta.
· Independent and research-based measurement data are not readily available for general public use.
· Lack of collaboration between key regulatory authorities.
· Laxity in the enforcement of emission regulations.

The system proposed in this study i.e closed loop control system "Nature- technogenics" will effectively solve four of the five factors listed above by monitoring emission, providing a consistent and systematic measurement as well as ensuring accurate data preservation while eliminating the human factor [1][10][11].

POLLUTION COMPONENTS AND SOURCES (COx , NOx, SOx)

Sulfur Oxides (SOx): Especially sulphur dioxide, SO2 is mainly produced by volcanoes and in various industrial processes. As coal and petroleum often contain sulphur compounds, their combustion generates sulfur dioxide. Further oxidation of SO2, usually in the presence of a catalyst such as NO2, forms H2SO4 and thus acid rain [6]. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.
Nitrogen Oxides (NOx): nitrogen dioxide which is one of the most prominent nitrogen oxides are emitted from high temperature combustion.
Carbon monoxide (CO): This is a product of incomplete combustion of fuel such as natural gas and coal automobile exhaust is a major source of carbon monoxide.
Carbon dioxide (CO2): this is a nontoxic greenhouse gas associated with ocean acidification, emitted from sources such as combustion, cement production and animal respiration.
Ammonia (NH3): This is emitted from agricultural processes. It is normally encountered as a gas with a characteristic pungent smell. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a originator to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both acerbic and hazardous.
Volatile organic compounds: VOCs are an important outdoor air pollutant. they are often divided into methane (CH4) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas adding to global warming.
Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukemia through prolonged exposure. Sources of particulate matter can be man made or natural.
Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols.
Averaged over the globe, anthropogenic aerosols those made by human activities-currently account for about 10% of the total amount of aerosols in our atmosphere. Increased levels

of fine particles in the air are linked to health hazards such as heart disease altered lung function and lung cancer [6][12][13].
Chlorofluorocarbons (CFCs): It is harmful to the ozone layer emitted from products most of which are currently banned from use.

CONTROL MEASURES IN PLACE AND THEIR SHORTCOMINGS

Nigeria in her quest to reduce emission of pollutants into the atmosphere especially through gas flaring in the oil producing areas of the nation, has not only made some international commitments by being part of the signatory countries of many international agreements to abate gas flaring, but has as well put in place some environmental laws to control pollution from industrial activities.

Some of The Environmental Pollution Control Laws are Summarized Below

Associated Gas Re-Injection Act and Regulations

An Associated Gas Re-Injection Act was enacted in 1979 as a law to prohibit gas flaring practice in Nigeria by the then Military government was enacted with a accommodated timeframe for oil operators in the country to develop gas utilization facility for associated gas. Later the Associated Gas Re-Injection Act of 2004 was enacted, and this law obligated oil companies in the nation to submit detailed programme to utilize gas in their various fields. This law prohibits the flaring of associated gas without the prime consent or permission from the Minister of Petroleum Resources.

The Nigeria's Policy Thrust on Atmospheric Protection

This policy aimed at regulating the air quality standards and natural gas utilization and conservation in Nigeria as contained in the National Policy on Environment. the policy has it that regional corporation to minimizing atmospheric transportation of gases (associated gases) is necessary. It also has the objectives of: continuous monitoring of air emissions and gaseous wastes (CO, CO2 ,NO, CH4, SO2 etc.) from oil companies, gas facilities and refineries; promotion of utilization of produced associated gases, thereby reducing gas flaring and production of greenhouse gases.

The Natural Gas Conservation and Development Policy

This policy has it that among other things as prerequisite to make oil and gas production sharing contracts (PSCs) possible, the oil companies must include in their contracts agreement gas utilization clauses.

Nigerian Management Act on Environment (Draft) of 2000

This draft on Nigerian Management Act on Environment (NEMACT) was prepared by the Nigerian Federal ministry of Environment as repeal to FEPA Act. This act presented some measures for the government to achieve gas flaring phase-out target and introduced criminal liability for any individual or corporate entity flaring gases. This act empowers the minister of environment to ban gas flaring but may give permission for flaring in certain circumstances (Sub-section (2) of section 20 of the draft Act). Adding jail term to the fine for defaulters [14][17].

Incentives to Encourage Gas Flaring Phase-Out In Nigeria

The government of Nigeria has introduced many incentives to encourage oil companies comply with gas flaring phase-out commitments. Knowing fully well those laws alone cannot do the job, the Nigerian government has fashion out some strategies to implement gas flaring phase-out other than through command-and-control [15]. Plants and machinery will receive 90% annual allowance. Such development will receive tax free dividends during the period of the tax holiday. Gas projects attract 30% taxation while oil related projects

attract 85% taxation by the government; These incentives were later improved 1998 by the Nigerian government to encourage more gas development projects to put gas flaring practices to an end, and at the same time generating profit for Nigerian government[15][17]. The improved incentives include:

1. The tax holiday period was extend from 3 years period to 5 years period with renewal possibility after 2 years;

2. The fiscal incentives are extended to other gas utilization projects such as power plant for electricity generation; fertilizer plants; gas distribution projects; transmission pipelines projects; gas to liquid projects;

3. Loans for gas projects are now made easier and the capital expenditure for gas projects chargeable under Petroleum Profits Tax (UNFCCC, 2009; J.D. Njoku, personal Interview, 5 April 2011);

4. Custom duties and VAT exemptions for gas related equipment being imported into the country for gas projects;

5. Another incentive is the lower gas royalty rate of 5% against 18.5% royalty from oil production.

PROPOSED APPROACH AND DISCUSSION

Open loop control system that led to the closed loop.

The open loop control system will the industrial management with their environmental and production departments, the government environmental protection agency, licensing agency, other natural resources and health control agencies. The system will also include the pollution concentration estimation and monitoring devices, used by these agencies to regulate air pollution. However, corruption is an inherent part of this system as long as implementation is done by human, most of which are easily corruptible hence the need for a system without the corruptible human factor.

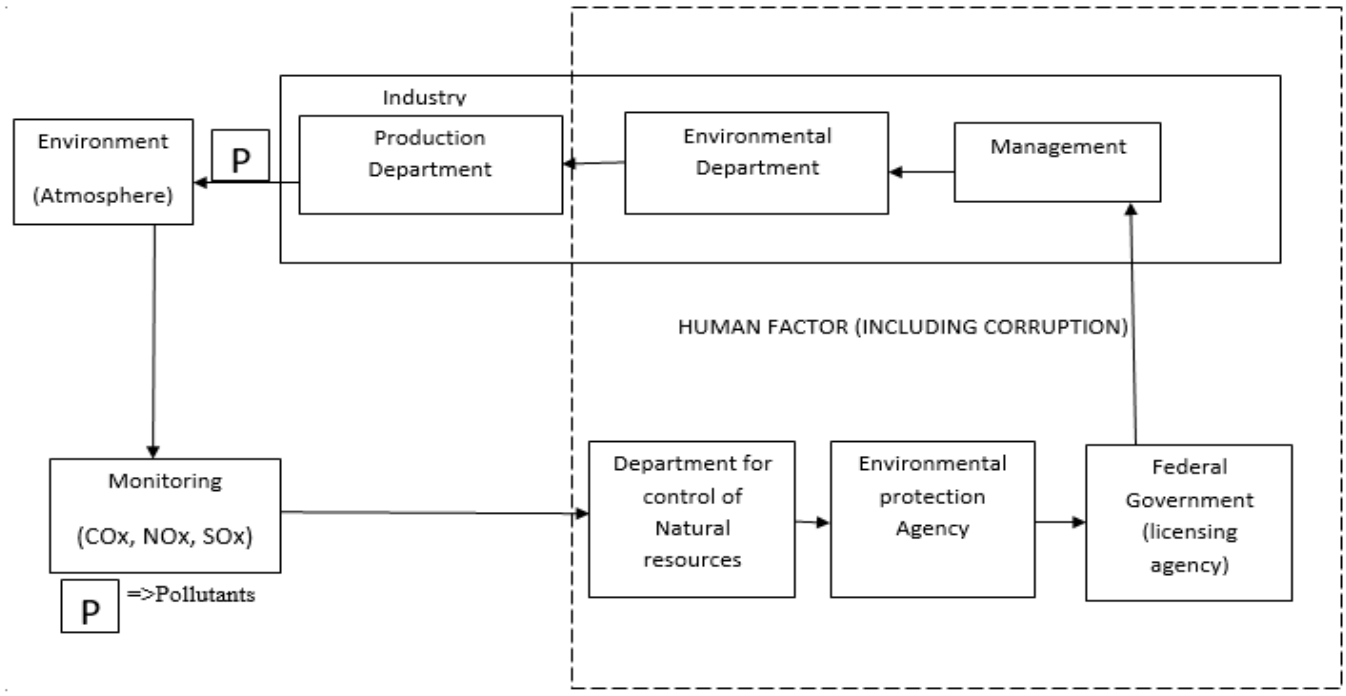


Figure 1: Pollution Control (Open Loop) System of Nature-Technogenics

Figure 1 above shows the existing open loop "nature-technogenic", which includes the human factor as necessarily decisive link with the management system. This gives room for bribery and corruption.

The closed loop control system "nature-tecnogenics"

In the works of Professor R.I. Solnitsev and his team (in Saint Petersburg Electrotechnical University Russia),a specific engineering solution concept of closed-loop control was proposed and developed which aims to minimize the human factor in environmental protection implementations, the exclusion of the "gap" between the results of the monitoring and control of the respective treatment units, no loss of information and, as a result, the economic costs related to compensation for accidents and fines [10]. This system effectively eliminates the human factor in pollution regulation thereby improving implementation and efficiency of the control measures stated above.

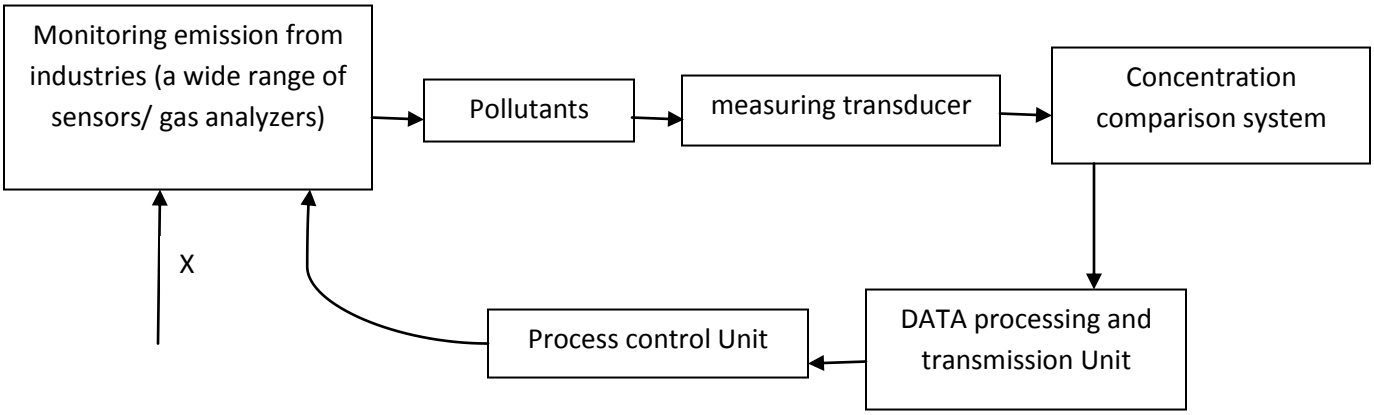
The development of such a complex system of management as closed loop control system "Nature- technogenics" would not be possible without application of modern information technologies, in particular, the development of CAD systems, providing the tasks of modeling, computation, control synthesis as well as design planning.

This systems comprise many subsystems; modeling subsystem, analysis, synthesis, design subsystem , a subsystem for processing the results of from the measuring instruments, technological preparation subsystem, subsystem of preparation of technical documentation. Though this system model is applicable in other types of pollution control like water, This article discusses the monitoring and control of pollutants emitted into the atmosphere.

The Closed loop system solves air pollution issues with direct inclusion of the human factor only as a series of acts, signatures and approvals of space hardware-software complexes (AIC), where the role of the human operator is reduced to monitoring the work of AIC and their individual elements (sensors, transmitters, controllers, actuators, etc.). This transition fundamentally reduces the emission pollution and removes the "human element" of direct connection to the system thereby minimizing corruption [1][10].

Closed loop control system components and their operation mechanism

The control circuit includes, amplifying and converting, computing, recording and actuator.



X=> air sample from sources of pollutants

Figure 2 Schematic of a closed loop control system "Nature-Technogenics"

With the help of mobile carriers, The measuring devices are placed in regions with highest concentration of pollutants. Hence, optimally protecting the environments. These mobile carriers could also be used for dry air chemical treatment, in which these mobile carriers can introduce reagents that can react with these pollutants to give a compound that is harmless to the environment.

The measuring transducers check the concentration of each pollutant in the sample while the concentration comparison system compares these concentrations with a preset allowed value. The result is then sent to the DATA processing unit which in turn relays it to the Process control unit for decision and corrective action depending on the concentration recorded. The cycle is then repeated [10].

It is note worthy that the Automatic control system "Nature-Technogenics" operates in real-time and has a section in the control unit responsible for transmitting information to a display device at all levels of management from sources of pollutants to the decision-makers at the federal level. Hence, both parties will have a good knowledge of the emission and have no complains about consequences.

CONCLUSION

The negative impact of pollution in general and air pollution in particulars cannot be over emphasized, the efforts of the Nigerian government towards reducing environmental pollution in most cases is being undermined by human factors like bribery and corruption, hence the need for the implementation aspect to be done mainly by an incorruptible system and we have shown "Nature-Technogenics" to be that incorruptible system. This work having analyzed the efforts made toward pollution control and their short-comings went further to describe how this closed loop system can rectify issues of the existing control measures in place.

The fact that the government is really concerned about environmental pollution control is not to be argued looking at her efforts so far to that direction. It is on this note, that we recommend the introduction of automatic control system "nature-technogenics" to enable their effort bear significant fruit within a short time. Also on this same note, we recommend that further research be supported by the government and industrial stakeholders on

1) Possible application of this system in vehicle emission control.
2) The possible application of this system in other environmental control not just atmospheric.
3) The extent this system can go in dry air chemical treatment (optimizing the system for this purpose).

This work is actually not suggesting a replacement for the existing measure, but is recommending an automatic control system supplement for the existing measures.

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