



Research article

Novel metric for managing the protection of humanity and the environment against pollution and its adverse effects

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ABSTRACT

Pollution prevention and control are very significant for protecting humanity and the environment against pollution and its adverse effects worldwide. The primary resistance of every country to the occurrence of any of the adverse effects of pollution is a function of the country's pollution prevention & control. Strengthening pollution prevention & control in a country is tantamount to preventing the occurrence of any of the adverse effects of pollution (including any of the pollution-related communicable diseases). Knowing the status of the pollution prevention & control in a country will enable its Government to plan and improve on it. This research work conducted a survey on the extent of availability of pollution prevention & control infrastructure, availability of environmental regulatory agencies and compliance of operating companies to environmental regulations in the Niger Delta. Based on the outcome of the survey, this work invented a novel composite metric titled "Pollution Prevention & Control Index" (PPCI) for measuring the status of pollution prevention & control in a country or region. It is a measure of the protection of the population and the environment against pollution and its adverse effects. Results revealed that the higher the pollution prevention & control index of a country, the smaller the work left undone (or the work to be done) to protect the environment and the population of the country against pollution, its adverse effects and vice versa. Results also showed that the generic pollution prevention & control index of a developed country is higher than that of a developing country.

1. Introduction

Environmental pollution poses several dangerous health effects to humanity from infancy to adulthood including perinatal diseases, infant mortality, respiratory diseases, allergy, malignancies, cardiovascular diseases, escalation of oxidative stress, endothelial dysfunction, mental disorders, increased risk of morbidity and mortality from many diseases, organ disorders, cancer and other chronic and non-chronic diseases (Kelishadi 2012). Air pollution resulting from combustion of fossil fuels and biomass and the consequential environmental impacts such as respiratory diseases, smog, acid rain and global warming are major threats to humanity and the environment (Testa et al., 2014). Wikipedia (2020b and c) stated that air pollution and water pollution are among the leading causes of deaths and diseases worldwide with air pollution accounting for the death of about 7 million people annually while water pollution was responsible for the death of 1.8 million people in year 2015. Wikipedia (2020d) wrote that soil pollution affects human health through direct

contact with the soil or inhalation of vaporized soil pollutants or intake of soil pollutants that have infiltrated into groundwater and it can cause diseases e.g. cancer, Leukemia, kidney damage, congenital disorders, liver disorders, depression of the central nervous system and death. Kjellstrom et al. (2006) reported that environmental pollution health risks to humanity affect almost every organ and they include infectious diseases relating to drinking water, respiratory diseases relating to indoor and outdoor pollution including diarrheal diseases, cancers, neurological disorders, cardiovascular diseases and vector-borne diseases with environmental component such as malaria.

The US Environmental Protection Agency (2020) stated that pollution prevention is the practice of reducing, eliminating or preventing pollution at source and that source reduction translates to less waste to control, treat or dispose of and reduced hazard to public health and the environment. Furthermore, pollution prevention enables improved health, reduces financial loss, protects the environment and increases economic growth through efficient production in

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industry. <http://encyclopedia.com/Encyclopedia.com> (2020) stated that pollution control means reducing or eliminating discharge of pollutants into the environment and it is regulated by environmental regulations that stipulate pollutant discharge limits for air, water and land. The US Clean Water Act regulates point-source discharge of effluents into surface waters. Testa et al. (2014) wrote that environmental regulations differ from country to country in terms of policies, legal tools, design and enforcement.

Pollution prevention and control are very significant for protecting humanity and the environment against pollution and its adverse effects. The primary resistance of a country to the occurrence of any of the adverse effects of pollution (including any of the pollution-related communicable diseases) is a function of its pollution prevention & control. The effectiveness of pollution prevention & control is a function of Government's commitment, environmental regulatory agencies, compliance of industries to environmental regulations and the extent or coverage of the pollution prevention & control infrastructure in a country. Full coverage of a country by the pollution prevention & control infrastructure should be the target of every Government. Strengthening pollution prevention & control in a country is tantamount to preventing pollution and the occurrence of any of the adverse effects of pollution including any of the pollution-related communicable diseases. Therefore, pollution prevention & control constitute the primary defense of every nation against the occurrence of any of the adverse effects of pollution. If there is occurrence of any of the pollution-related communicable diseases, it may transverse developing and developed countries and put to test the effectiveness of the disease control units in the affected countries. This implies that pollution prevention & control precede disease control. This awareness calls for a stronger global attention on pollution prevention & control to further protect humanity and the environment alongside reducing healthcare cost and the burden on the various "Centers for Disease Control (CDC)" across the world. Therefore, there is an urgent need for a global metric to measure the status of pollution prevention & control in every country or region. Knowing the status of pollution prevention & control in a country or region will enable the Government to plan and improve on it.

Traditional pollution prevention & control indexes such as Air quality indexes, Water quality indexes and Soil quality indexes are focused on different aspects of the environment, air or water or soil alone and they do not consider the extent of availability of relevant infrastructure and other human inputs that are critical to the protection of humanity and the environment. The aforesaid and the tremendous threat to humanity by soil, water and air pollution coupled with the natural transport of pollutants in same or converted forms between soil, water and air justify the need for a composite index for evaluating the protection of humanity and the environment against pollution and its adverse effects in every region or country.

In view of the foregoing, this research work conducted a survey in six states of the Niger Delta to ascertain the extent of availability of pollution prevention & control infrastructure, availability of environmental regulatory agencies and compliance of companies to environmental regulations. Based on the outcome of the survey, this work invented a novel composite metric titled "Pollution Prevention & Control Index" (PPCI) to measure the status of pollution prevention & control in any country or region. It is a measure of the protection of a country's population and environment against pollution and its adverse effects. It has global applicability. It can be applied in every country or region.

2. Materials & methods

This research work conducted a survey covering 18 cities (state capitals & county headquarters), 18 towns, 18 villages, 18 hamlets and 32 companies in the Niger Delta regarding the availability of pollution prevention & control infrastructure, availability of regulatory agencies and compliance of operating companies to environmental regulations in the Niger Delta. For the purpose of this survey, cities were defined as

state capitals and county headquarters only. The results are as presented in Table 1. Based on the outcome of the survey, a novel composite metric titled "Pollution Prevention & Control Index" (PPCI) was invented to measure the status of pollution prevention & control in a country or region.

3. Results & discussion

The survey revealed that companies discharge untreated wastewaters into receiving water bodies as presented in Table 1. None of the companies investigated has wastewater treatment plant. Oguzie and Okhagbuzo (2010) reported that untreated effluents from domestic, industrial and agricultural sources containing various pollutants including heavy metals are discharged into drains, soils and receiving water bodies in Benin, Nigeria. Azimi et al. (2017) wrote that industrialization introduces heavy metals into the environment (air, water and land); the heavy metals being easily absorbed by fishes and vegetables because of their high solubility in the aquatic environments. Fair et al. (1981) stated that wastewater discharges to receiving water bodies must satisfy regulations established by the regulatory Governmental agencies.

Discharging untreated industrial wastewaters into receiving water bodies renders them unfit for drinking, recreational activities and fishing. This unsafe situation implies weak regulation or no regulation by the relevant environmental regulatory agencies and confirmed that pollution prevention & control in a country or region is a function of the effectiveness of the environmental regulatory agencies. The survey also revealed as presented in Table 1 that public potable water supply is not available in any of the cities, towns, villages and hamlets investigated and this explains why water boreholes and water wells are the primary sources of drinking water in the Niger Delta. The coastal communities drink from the receiving water bodies because of lack of public potable water supply. Barakat (2011) stated that ingesting heavy metals beyond allowable concentrations causes serious health disorders.

Indiscriminate disposal of solid waste is commonplace in the Niger Delta as revealed by the survey and presented in Table 1, partly because there are no solid waste disposal receptacles on every street. Many companies in the Niger Delta contract their solid waste collection and disposal to local contractors as part of corporate social responsibility to their host communities. The Government's waste management drive in the Niger Delta is mainly focused on solid waste management to the neglect of industrial wastewaters and air quality management as evidenced by the fact that the monthly environmental sanitation days declared by Government are always for solid waste collection and disposal. The aforesaid neglect of industrial wastewaters and air quality management confirmed that pollution prevention and control in a country or region is also a function of Government's commitment. Furthermore, the monthly environmental sanitation days declared by Government are enforced in the state capitals and county headquarters only; partly because there are no environmental regulatory agencies in other towns, villages and hamlets; confirming that pollution prevention & control in a country or region is also a function of the availability of environmental regulatory agencies.

Afun (2009) reported that the practice of indiscriminate disposal of solid waste in Nigeria is hazardous to the ecosystem and the people because solid waste deposited on land generates emissions that pollute the environment and become breeding ground for disease-bearing animals and micro-organisms. Furthermore, people frequently burn dry accumulated solid waste openly in Nigeria, thus posing a major threat as the burning materials emit dangerous gases into the atmosphere. Uwagbale (2016) stated that there are enough laws and regulations for the management of solid waste in Nigeria but the regulatory agencies are not sufficiently empowered to enforce the regulations. Kjellstrom et al. (2006) stated that managing air pollution interventions, requires monitoring of air quality and the technologies for reducing air pollution, warning that air pollution problems to humanity include acute respiratory infections, cardiovascular diseases, asthma, lung cancer, lead

Table 1. Pollution Prevention & Control Index of a developing Country - Generic.

| S/N | Pollution Prevention & Control parameters | Pollution Prevention & Control rating | Yes/No | Pollution Prevention & Control Index score | Remarks |
|-----|---|---------------------------------------|--------|--|--|
| 1 | Is public potable water supply available in every hamlet, village, town or city? In every: | | | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 (if all are Yes). |
| | City | 0.25 | No | | |
| | Town | 0.25 | No | | |
| | Village | 0.25 | No | | |
| | Hamlet | 0.25 | No | | |
| 2 | Are there statutory laws and regulations for regulating pollutants in wastewater, solid waste and air? | 1 | Yes | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if No). |
| 3 | Are Environmental Regulatory Agencies available in every hamlet, village, town or city? In every: | | | 0.25/13 = 0.0192 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if all are Yes). |
| | City | 0.25 | Yes | | |
| | Town | 0.25 | No | | |
| | Village | 0.25 | No | | |
| | Hamlet | 0.25 | No | | |
| 4 | Is there strict enforcement of environmental laws, regulations and associated penalties? | 1 | No | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if Yes). |
| 5 | Do companies always treat wastewaters to reduce heavy metal content and other pollutants to within or exact statutory limits before disposal? | 1 | No | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if Yes). |
| 6 | Do companies dispose of untreated wastewaters? | 1 | Yes | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if No). |
| 7 | Are all the drains conveying wastewaters in every hamlet, village, town or city to the receiving water bodies; impervious (concreted) and covered (concrete slabs)? In every: | | | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if all are Yes). |
| | City | 0.25 | No | | |
| | Town | 0.25 | No | | |
| | Village | 0.25 | No | | |
| | Hanlet | 0.25 | No | | |
| 8 | Are all companies sited exclusively in Government-approved industrial areas, void of residential houses and nearest residential house located beyond 500m radius? | 1 | No | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if Yes). |
| 9 | Is Solid waste disposal (industrial, agricultural & domestic) always done at approved receptacles and impervious (concreted) dump sites in every hamlet, village, town or city? In every: | | | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if all are Yes). |
| | City | 0.25 | No | | |
| | Town | 0.25 | No | | |
| | Village | 0.25 | No | | |
| | Hamlet | 0.25 | No | | |
| 10 | Is public solid waste (industrial, agricultural & domestic) treatment available in every hamlet, village, town or city? In every: | | | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if all are Yes). |
| | City | 0.25 | No | | |
| | Town | 0.25 | No | | |
| | Village | 0.25 | No | | |
| | Hamlet | 0.25 | No | | |
| 11 | Are public wastewater (industrial, agricultural & domestic) and other liquid waste disposal done at/through approved receptacles/channels and treatment available in every hamlet, village, town or city? In every: | | | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if all are Yes). |
| | City | 0.25 | No | | |
| | Town | 0.25 | No | | |
| | Village | 0.25 | No | | |
| | Hamlet | 0.25 | No | | |
| 12 | Does the country or region use fossil fuel as a source of energy and/or for power generation and/or to power vehicles, aircrafts and watercrafts? | 0.5 | Yes | 0 | Population is vulnerable. Pollution prevention & control score = 0.5/13 (if No for use of fossil fuel) but it is 0.5/13 if Yes (for use of renewable energy) to give total score of 1/13 = 0.0769. |
| | Does the country or region use renewable energy sources for power generation and to power vehicles, aircrafts and watercrafts? | 0.5 | No | | |

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Table 1 (continued)

| S/N | Pollution Prevention & Control parameters | Pollution Prevention & Control rating | Yes/No | Pollution Prevention & Control Index score | Remarks |
|-----|---|---------------------------------------|--------|--|---|
| 13 | Is air quality monitoring done regularly in every hamlet, village, town or city with appropriate measures taken and the people advised accordingly? In every: | | | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if all are Yes) |
| | City | 0.0625 | No | | |
| | Town | 0.0625 | No | | |
| | Village | 0.0625 | No | | |
| | Hamlet | 0.0625 | No | | |
| | Are air pollution reduction technologies and pollutant emission limits enforced on every vehicle – car, truck, train etc; every aircraft, rocket, space shuttle etc; every watercraft - ship, boat, submarine, etc? | 0.25 | No | | |
| | Are air pollution reduction technologies and pollutant emission limits enforced on every power plant? | 0.25 | No | | |
| | Are air pollution reduction technologies and pollutant emission limits enforced on every industrial plant, oil & gas wells and processing units ? | 0.25 | No | | |
| | TOTAL | | | 0.0961 | |

poisoning and damage to the central nervous system. Afun (2009) wrote that poor waste management in Nigeria can be attributed to ignorance; weak regulation; non-enforcement of existing regulations; lack of solid waste management hierarchy and lack of public enlightenment.

Analyzing the results of the survey with a view to extending the benefits to every country in the world, prompted the invention of a novel composite metric titled “Pollution Prevention & Control index” (PPCI) in this research work. It is a measure of the protection of the population and environment in a country or region against pollution and its adverse effects. The PPCI is a measure of the work that has been done and the work left to be done by Government to protect the population and the environment against pollution and its adverse effects. The application of the pollution prevention & control index involves honestly and meticulously weighing a country or region against the “pollution prevention & control parameters” listed in the template (Table 1 or 2). The parameters are same for Tables 1 and 2 and they are common to every country. Applying the results of the survey to weigh Nigeria against the parameters (the results are similar to my experience in three other African countries) a generic pollution prevention & control index (PPCI) for a developing country can be calculated as in Table 1: The method for calculating the pollution prevention & control index in Tables 1 and 2 is as follows:

- i) Items in each numbered row constitute a PPCI parameter while each item among the items in a row constitute a sub-parameter
- ii) The pollution prevention & control (PPC) rating of each parameter = 1
- iii) There are a total of 13 parameters making the total PPC rating = 13
- iv) The PPC rating of each sub-parameter = $\frac{1}{\text{No of sub-parameters in the row}}$
- v) PPCI score for each parameter = $\frac{\text{sum of PPC ratings of available/done sub-parameters}}{13}$
- vi) Apply the comments in the Remarks Column
- vii) The PPCI of a country or region = Sum of the PPCI scores of all the parameters

Abdulmumini et al. (2015) reported that industrial wastewaters are discharged into receiving water bodies without treatment in Nigeria with the consequences of loss of aquatic life, disease burden and short life expectancy. Nwufo (2010) stated that enforcement of environmental laws by the regulatory agencies in Nigeria has been with limited success because it has been plagued with problems. Ogbonna, Ekweozor and Igwe (2002) reported that indiscriminate disposal and dumping of waste is commonplace in most Nigeria cities and many companies dispose untreated waste into nearby creeks or open dumpsites. Ogolo (2011) in

his study on waste management development conducted in five states of the Niger Delta namely Bayelsa State, Delta State, Rivers State, Akwa Ibom State and Cross River State reported that indiscriminate dumping of refuse is one of the factors militating against the health of the people. Amnesty international (2018) reported that there is urgent need to ensure regular supply of potable water to the people in the oil producing communities of the Niger Delta because their right to water is being violated as they are compelled to drink polluted water. Maduka and Ephraim-Emmanuel (2019) reported that crude oil exploration and associated harmful activities such as oil spills and gas-flaring have adversely affected the health of the people and the biological, economic and socio-cultural life of the oil bearing communities in the Niger Delta. Adeola et al. (2015) reported that drinking water sampled from water boreholes in Elioizu community, Rivers state were contaminated and he recommended regular monitoring of the physico-chemical properties of groundwater sources in Elioizu and other parts of the Niger Delta to ensure safe drinking water for the people.

Based on my experience in four developed countries and weighing same against the pollution prevention & control parameters (with assumptions where necessary), a generic pollution prevention & control index for a developed country can be calculated as in Table 2.

Wikipedia (2020a) stated that a developed country is a sovereign state that has a developed economy and advanced technological infrastructure with the service sector providing more wealth than the industrial sector while developing countries are those in the process of industrialization where the industrial sector dominates the service sector emphasizing that developed and developing countries can be classified based on any of the following:

- i) Income per capita. Countries with high gross domestic product (GDP) per capita are classified as developed.
- ii) Industrialization. Countries in which the tertiary and quaternary sectors of industry dominate are described as developed countries
- iii) Human development Index (HDI). The HDI is a statistical index that measures a country's level of human development using nominal income, life expectancy and education taking into account how income is turned into education and health opportunities and therefore into higher levels of human development. Countries with very high human development index (0.8–1.0) are classified as developed while developing countries are those with low to high human development index (0–0.799). Some examples of developed countries are Norway, Germany, United Kingdom, France, Canada and the United States of America while some examples of developing countries are Ecuador, Ghana, Afghanistan, Brazil, Georgia and Nigeria.

Table 2. Pollution Prevention & Control Index of a developed Country - Generic.

| S/N | Pollution Prevention & Control parameters | Pollution Prevention & control rating | Yes/No | Pollution Prevention & control index score | Remarks |
|-----|---|---------------------------------------|--------|--|--|
| 1 | Is public portable water supply available in every hamlet, village, town or city? In every: | | | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if all are No). |
| | City | 0.25 | Yes | | |
| | Town | 0.25 | Yes | | |
| | Village | 0.25 | Yes | | |
| | Hamlet | 0.25 | Yes | | |
| 2 | Are there statutory laws and regulations for pollutants in wastewaters, solid waste and air? | 1 | Yes | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if No). |
| 3 | Are Environmental Regulatory Agencies available in every hamlet, village, city or town? Available in every: | | | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if all are No). |
| | City | 0.25 | Yes | | |
| | Town | 0.25 | Yes | | |
| | Village | 0.25 | Yes | | |
| | Hamlet | 0.25 | Yes | | |
| 4 | Is there strict enforcement of environmental laws, regulations and associated penalties? | 1 | Yes | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if No). |
| 5 | Does every company always treat wastewaters to reduce heavy metal content and other pollutants to within or exact statutory limits before disposal? | 1 | No | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if Yes). |
| 6 | Do companies dispose of untreated wastewaters? | 1 | No | 1/13 = 0.0769 | The population is less vulnerable. Pollution prevention & control score = 0 (if Yes). |
| 7 | Are all the drains conveying wastewaters in every hamlet, village, town or city to the receiving water bodies impervious (concreted) and covered (concrete slabs)? In every: | | | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if all are No). |
| | City | 0.25 | Yes | | |
| | Town | 0.25 | Yes | | |
| | Village | 0.25 | Yes | | |
| | Hamlet | 0.25 | Yes | | |
| 8 | Are all companies sited exclusively in Government-approved industrial areas, void of residential houses and nearest residential house located beyond 500m radius? | 1 | No | 0 | The population is vulnerable. Pollution prevention & control score = 1/13 = 0.0769 (if Yes). |
| 9 | Is solid waste (industrial, agricultural & domestic) disposal always done at approved receptacles and impervious (concreted) dump sites in every hamlet, village, town or city? In every: | | | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if all are No). |
| | City | 0.25 | Yes | | |
| | Town | 0.25 | Yes | | |
| | Village | 0.25 | Yes | | |
| | Hamlet | 0.25 | Yes | | |
| 10 | Is public solid waste (industrial, agricultural & domestic) treatment available in every hamlet, village, town or city? In every: | | | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if all are No). |
| | City | 0.25 | Yes | | |
| | Town | 0.25 | Yes | | |
| | Village | 0.25 | Yes | | |
| | Hamlet | 0.25 | Yes | | |
| 11 | Are public wastewater (industrial, agricultural & domestic) and other liquid waste disposal done at/through approved receptacles/channels and treatment available in every hamlet, village, town or city? In every: | | | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if all are No). |
| | City | 0.25 | Yes | | |
| | Town | 0.25 | Yes | | |
| | Village | 0.25 | Yes | | |
| | Hamlet | 0.25 | Yes | | |
| 12 | Does the country or region use fossil fuel as a source of energy and/or for power generation and/or to power vehicles, aircrafts and watercrafts? | 0.5 | Yes | 0.5/13 = 0.0385 | The population is vulnerable. Pollution prevention & control score = 0.5/13 (if No for use of fossil fuel) but it is 0.5/13 if Yes (for use of renewable energy) to give a total of 1/13 = 0.0769. |
| | Does the country or region use renewable energy sources for power generation and to power vehicles, aircrafts and watercrafts? | 0.5 | Yes | | |

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Table 2 (continued)

| S/N | Pollution Prevention & Control parameters | Pollution Prevention & control rating | Yes/No | Pollution Prevention & control index score | Remarks |
|-----|---|---------------------------------------|--------|--|--|
| 13 | Is air quality monitoring done regularly in every hamlet, village, town or city with appropriate measures taken and the people advised accordingly? In every: | | | 1/13 = 0.0769 | The population is not vulnerable. Pollution prevention & control score = 0 (if all are No) |
| | City | 0.0625 | Yes | | |
| | Town | 0.0625 | Yes | | |
| | Village | 0.0625 | Yes | | |
| | Hamlet | 0.0625 | Yes | | |
| | Are air pollution reduction technologies and pollutant emission limits enforced on every vehicle – car, truck, train etc; every aircraft, rocket, space shuttle etc; every watercraft - ship, boat, submarine, etc? | 0.25 | Yes | | |
| | Are air pollution reduction technologies and pollutant emission limits enforced on every power plant? | 0.25 | Yes | | |
| | Are air pollution reduction technologies and pollutant emission limits enforced on every industrial plant, oil & gas wells and processing units? | 0.25 | Yes | | |
| | | | | TOTAL | 0.8075 |

Environmental policies differ from country to country (Testa et al., 2014). For example, the US Environmental Protection Agency (2020) stated that the US Pollution Prevention Act established the national policy stating that:

- Pollution should be prevented or reduced at the source whenever feasible;
- Pollution that cannot be prevented should be recycled in an environmentally safe manner whenever feasible;
- Pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and
- Disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.

The Nigerian National Environmental Standards Regulation Agency (2017) stated Nigeria's environmental policy as:

- Environmental concerns are integrated into major economic decision-making process;
- Environmental remediation costs are built into major development projects;
- Economic instruments are employed in the management of natural resources;
- Environmentally friendly technologies are applied;
- Environmental impact assessment is mandatorily carried out before any major development project is embarked on.

The generic pollution prevention & control index of a developed country is higher than that of a developing country as evidenced by Tables 1 and 2. This implies that developing countries have more work left undone or more work to do to protect their respective populations and environment against pollution and its negative effects. In other words, developing countries have greater pollution prevention & control indebtedness than developed countries. It is evident from Tables 1 and 2 that the generic pollution prevention & control index of a developing country is 0.0961 while that of a developed country is 0.8075. Pollution prevention & control index of 1 indicates no work left to be done on pollution prevention & control but it is not achievable in practice. It can also be deduced from Tables 1 and 2 that when a developed country and a developing country are both hit by an environmental pollution disaster of same magnitude, the people of the developing country will be worse

affected by the disaster. This is consistent with the fact that the developed country has higher pollution prevention & control index than the developing country. This also implies that communities living near a heavy-polluting company in a developing country are more vulnerable to the toxic effects of the company's emissions and effluents than communities living near same company in a developed country. This suggests that Government should prohibit residential houses from being built near companies or near industrial areas. Industrial areas should be created and restricted to companies only. No residential house should be within 500 m distance (if possible) from any company or any industrial area.

It is evident from Tables 1 and 2 that the novel pollution prevention & control index is a measure of what Government has put in place (and what is not available) for the protection of the people and the environment (land, water and air) against pollution and its adverse effects. Therefore, the PPCI is a measure of the status of pollution prevention and control in any region or country. Pollution prevention & control index of a value less than 1 indicates that further investment is required for pollution prevention & control in a country or region. Therefore, the pollution prevention & control index can be applied as appropriate, to assess the exposure of the people and the environment to the toxic effects of pollution in any region or country. It will be a valuable working tool for every country or region, environmental regulatory agencies, professional bodies, research centres, polytechnics; universities and other educational institutions worldwide.

The PPCI will enable Government of every country to periodically assess what it has already provided and what it has not provided for pollution prevention & control and prompt adequate corrective measures. In other words, the PPCI is a measure of the pollution prevention & control indebtedness of a country. Tables 1 and 2 revealed that the higher the pollution prevention & control index, the less work left to be done by the Government to protect the population and the environment against pollution and its adverse effects and vice versa. It can also be deduced from Tables 1 and 2 that as the Government of a country improves on pollution prevention & control, the pollution prevention & control index of the country increases.

The Federal Government of every country can apply the pollution prevention & control index (PPCI) as appropriate to classify all the states in their respective countries and inspire competition to increase PPCI among the various states and this will lead to better environmental protection, better health, longer and better life for humanity worldwide. Similarly, the pollution prevention & control index can also be applied as appropriate by State Governments in every country to classify counties

Table 3. Traditional Pollution Prevention & Control indexes and the Novel Pollution Prevention & Control Index (PPCI).

| S/N | What has been? | What is new? |
|-----|---|--|
| 1 | Current (Traditional) pollution prevention & control indexes are focused on different aspects of the environment, Land, or water or air alone e.g. air quality indexes, water quality indexes and soil quality indexes. The MSCI Global Pollution Prevention index is revenue-based. It is based on revenues made by markets and companies that derive 50% or more of their revenues from products and services in pollution prevention globally. | The novel pollution prevention & control index (PPCI) is a direct composite index and it covers land, water and air. |
| 2 | Traditional pollution prevention & control indexes are quantitative measures e.g. the US air quality index, the UK air quality index and the Canadian air quality health index are based on the concentrations of specific pollutants in air. Similarly, water quality indexes measure magnitude of water quality parameters. The MSCI Global Pollution Prevention index is revenue-based. | The PPCI is a qualitative metric that measures the status of pollution prevention & control in a country or region. |
| 3 | Traditional pollution prevention & control indexes (e.g. air, or water or soil quality index) measure the concentrations of pollutants or magnitude of quality parameters based on which decisions are made by responsible authorities and communicated to the public on actions required to avoid/reduce the adverse effects. | The PPCI measures what has been done to protect the population and the environment against pollution and its adverse effects and the actions required to improve pollution prevention and control. |
| 4 | Not part of traditional pollution prevention & control indexes | The PPCI considers the extent of availability of pollution prevention & control infrastructure in a country or region. |
| 5 | Not part of traditional pollution prevention & control indexes | The PPCI takes into account the types of pollution sources in a region or country and the technologies deployed to control their discharges and associated adverse effects. |
| 6 | Not part of traditional pollution prevention & control indexes | The PPCI recognizes the availability and enforcement of environmental laws and regulations for pollution prevention & control. |
| 7 | Not part of traditional pollution prevention & control indexes | The PPCI considers the extent of availability of environmental regulatory agencies in a country or region. |
| 8 | Not part of traditional pollution prevention & control indexes | The PPCI accounts for extent of waste disposal receptacles and dumpsites in a country or region. |
| 9 | Not part of traditional pollution prevention & control indexes | The PPCI recognizes the extent of availability of waste treatment facilities in a country or region. |
| 10 | Not part of the traditional pollution prevention & control indexes | The PPCI takes into account the compliance of companies and the population to environmental laws and regulations in a country or region |

and generate competition between counties to increase their individual pollution prevention & control index and promote protection of humanity and the environment against pollution and its toxic effects. Continental and other regional bodies worldwide can also trigger competition among their member countries to increase their PPCI for the betterment of humanity and the global environment. The [US Environmental Protection Agency \(2020\)](#) stated that pollution prevention reduces financial costs (waste management and cleanup) and environmental costs (health problems and environmental damage) and protects the environment by conserving and protecting natural resources alongside increasing economic growth through more efficient production in industry and less need for domestic, industrial and communal waste management.

The benefits of the pollution prevention & control index also extend to plants and animals in aquatic and terrestrial environment because the index covers pollution prevention and control on land, water and air. Hence, the application of the pollution prevention & control index will also enable improved plant and animal lives on land and water alongside improved recreational activities, fishing and other economic activities in coastal communities worldwide.

Traditional pollution prevention & control indexes include the air quality indexes available in many countries e.g. the US air quality index ([AirNow 2020](#)), UK daily air quality index ([Wikipedia 2020e](#)), the Canadian air quality health index ([Wikipedia 2020e](#)) and regional indexes e.g. the Quebec air quality index ([Iqa.environnement, 2020](#)). Others are the water quality index ([Tunc Dede et al., 2013](#)), the global drinking water quality index ([UNEP GEMS/Water Programme Office, 2007](#)), soil quality index ([Amacher, O'Neil and Perry 2007](#)) and the MSCI Global Pollution Prevention index (<http://msci.com/MSCI.com, 2020>) which is based on revenue of markets and companies that derive 50% and more of their revenues from products and services in pollution prevention.

The novelty inherent in the novel pollution prevention & control index (PPCI) becomes more glowingly evident when it is compared with the traditional pollution prevention & control indexes as presented in [Table 3](#).

The significance of the novel pollution prevention & control index cannot be over-emphasized. The limitation encountered during this research work was funding.

4. Conclusion

It is evident from the foregoing that the novel pollution prevention & control index (PPCI) will be beneficial for the protection of humanity and the environment against pollution and its adverse effects. The higher the pollution prevention & control index of a country or region, the smaller the work left undone (or the work to be done) to protect the environment and the population of the country or region against pollution, its adverse effects and vice versa. The generic pollution prevention & control index of a developed country (0.8075) is higher than that of a developing country (0.0961). The pollution prevention & control index has global applicability. It can be applied in every country.

As the Government of every country or region adopts the novel pollution prevention & control index to periodically evaluate the status of the respective country or region in pollution prevention & control and take appropriate remedial measures, there will be improvement in environmental quality, health, recreational activities, economic lives and life expectancy for humanity. Future work will include evaluating the effectiveness of the application of the PPCI in any country or region that has adopted it.

The Pollution Prevention & Control Index will be a valuable working tool to every country or region, United Nations, World Bank, International Monetary Fund, World Health Organization, regional and continental bodies worldwide.

Declarations

Author contribution statement

William E. Odiete: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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The author declares no conflict of interest.

Additional information

No additional information is available for this paper.

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