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Research Article

COMPARING ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL RISK ASSESSMENT METHODS AND SIGNIFICANCE

Nnena Ugochi Iwuanyanwu

Department of Geology, Federal University of Technology, Owerri, Nigeria.

Abstract

Environmental Impact Assessment (EIA) and Environmental Risk Assessment (ERA) are both essential tools used to evaluate and manage the effects of human activities on the environment. EIA focuses on the potential positive or negative impacts a proposed project may have on the environment, encompassing natural, social, and economic aspects. It involves identifying, predicting, evaluating, and mitigating these impacts before decisions are made. EIA is commonly used for specific projects, whereas Strategic Environmental Assessment (SEA) is applied to policies and programs. On the other hand, ERA assesses the likelihood and severity of environmental harm caused by business activities or operations, considering potential risks to both human health and ecological systems. This includes analyzing the potential hazards and impacts before implementing measures to reduce associated risks. Although EIA tends to be broader and more project-specific, ERA involves a more detailed, quantitative analysis of risks, particularly with respect to regulatory concerns. The paper discusses the key concepts, steps, and significance of both EIA and ERA, highlighting their differences and similarities. Case histories of both assessments are also presented, illustrating their practical applications and impact on environmental decision-making. By exploring the methods and importance of both assessments, the paper emphasizes the role these tools play in ensuring sustainable development and mitigating environmental harm.

Keywords: Environmental Impact Assessment, Environmental Risk Assessment, Risk Management, Environmental Decision-making, Sustainability

Introduction:

Concepts and Scope of Environmental Impact Assessment and Environmental Risk Assessment

The growing concern for environmental sustainability and protection in the wake of rapid industrialization, urbanization, and population growth has heightened the significance of systematic evaluation and management of potential environmental risks. The introduction of Environmental Impact Assessment (EIA) and Environmental Risk Assessment (ERA) as pivotal tools in environmental management reflects an increasing recognition of the need to account for the potential consequences of human activities on ecosystems, biodiversity, and the general well-being of the planet. Both EIA and ERA aim to safeguard the environment by providing a structured process for identifying, evaluating, and mitigating the negative environmental effects of proposed projects or activities.

Environmental Impact Assessment (EIA) is a key component of environmental governance, ensuring that the potential effects of a development proposal—whether positive or negative—are thoroughly examined before any major decisions are made. The concept of EIA was first introduced to evaluate the potential impacts of development projects on the environment, taking into account the interplay between the natural environment, social systems, and economic considerations (Mackinnon et al., 2018; Eccleston, 2011). It serves as an essential environmental management tool that assists in decision-making and project approval. The International Association for Impact Assessment (IAIA, 2012) defines EIA as the process of identifying, predicting, evaluating, and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions and commitments being made. The use of EIA enables developers, stakeholders, and governments to make informed decisions that balance developmental goals with environmental conservation and sustainability.

The scope of EIA is broad and covers a variety of project types and scales. It can be applied to construction projects, such as the development of infrastructure, energy plants, and urban expansion; natural resource extraction activities, including mining and oil drilling; industrial operations; and agricultural practices. When special consideration is paid to the social effects of the project, the process may be referred to as Environmental and Social Impact Assessment (ESIA). ESIA incorporates both environmental and social dimensions, focusing on the human impacts of a project in addition to the biophysical effects.

EIA typically involves several steps, including scoping, screening, impact prediction, assessment, mitigation measures, and the development of an Environmental Management Plan (EMP). The goal of this process is to provide decision-makers with an understanding of the potential risks and benefits of a project before it is executed. By predicting potential impacts, EIA allows for the identification of environmentally friendly alternatives and mitigation strategies that can reduce adverse effects, and it ensures that the environmental, economic, and social implications of the project are understood and managed. An essential feature of EIA is its requirement for public participation and consultation, which helps to enhance transparency and build trust between developers, regulators, and the communities affected by the project.

Environmental Risk Assessment (ERA), while related to EIA, focuses more specifically on identifying and quantifying the likelihood of adverse effects caused by environmental hazards and stressors on human health and ecological systems. Risk assessment is a process that evaluates the probability and severity of harmful outcomes arising from exposure to potential environmental threats. As such, ERA is crucial in determining the level of risk posed by pollutants, chemical substances, and other environmental stressors. The process generally involves hazard identification, dose-response assessment, exposure assessment, and risk characterization. This systematic approach allows decision-makers to assess the nature of potential environmental hazards, predict the associated risks, and develop appropriate strategies for risk management.

Environmental risk is typically defined as the actual or potential threat of adverse effects on living organisms and the environment, stemming from factors such as pollutants, emissions, resource depletion, and other anthropogenic activities. Risks may arise from various sources, including air pollution, hazardous waste, chemical spills, or deforestation. Risk assessments determine the likelihood and severity of a particular risk, whether it pertains to human health, animal life, or environmental degradation. By evaluating environmental hazards, ERA enables organizations to make informed decisions about their activities and adopt preventive measures or mitigation strategies to reduce risks.

A key characteristic of ERA is its ability to assess the risks posed by various environmental stressors, whether physical, chemical, or biological in nature. These stressors may include pollutants such as heavy metals, pesticides, and industrial chemicals, or environmental factors such as temperature fluctuations, habitat loss, or ecosystem disturbances. ERA can assess both short-term and long-term risks, evaluating both the immediate impacts and the cumulative effects of environmental hazards. For example, an ERA might assess the potential health risks of a community exposed to air pollution from industrial sources, evaluating both the short-term effects, such as respiratory issues, and long-term effects, such as cardiovascular diseases and cancer.

Unlike EIA, which focuses on a specific development proposal, ERA can be applied more broadly to analyze risks in a variety of contexts, ranging from industrial operations to urban planning, land use, and agricultural practices. One of the significant challenges in environmental risk assessment is the inherent uncertainty in predicting the potential consequences of environmental stressors. As a result, ERA often involves the use of sophisticated modeling techniques and statistical analyses to estimate the probability and impact of a risk. The results of these assessments are typically expressed either quantitatively, using numerical values to estimate risk levels, or qualitatively, providing a more descriptive analysis of risk. The ultimate goal of ERA is to inform decision-making by identifying the most effective strategies for reducing or managing environmental risks, whether through policy interventions, technological innovations, or changes in behavior.

Both EIA and ERA are integral to the management of environmental risks, particularly in the face of growing concerns about climate change, resource depletion, pollution, and biodiversity loss. They represent two of the key tools available to environmental managers, regulators, and policymakers to assess and mitigate the environmental impacts of human activities. EIA ensures that the potential effects of development projects are properly understood and addressed, while ERA provides a means of quantifying and managing environmental risks that may affect public health and the environment over the long term.

Despite their significance, both EIA and ERA face several challenges in their application. One key challenge is the complexity and unpredictability of environmental systems, which often makes it difficult to accurately assess the full range of potential impacts and risks. For example, the effects of climate change are inherently uncertain and may vary significantly depending on the specific geographic location, time frame, and sectoral focus. Moreover, the social dimensions of environmental risk, such as the vulnerability of different populations to environmental hazards, may be difficult to quantify and incorporate into assessments. Critics of traditional risk assessment approaches, such as Barry Commoner and Brian Wynne, have argued that these methodologies tend to oversimplify environmental risks, overlooking the complex, multifaceted nature of environmental threats and the diverse ways in which these risks are experienced by different communities (Kasperson et al., 1988; Commoner & O'Brien, 2002).

Furthermore, the over-reliance on quantitative approaches in risk assessment has led some experts, including Nassim Nicholas Taleb, to question the validity of traditional risk models. Taleb argues that risk assessment tends to ignore the potential for extreme events or "black swan" occurrences that are difficult to predict but can have catastrophic consequences (Taleb, 2008). In response to these concerns, some scholars advocate for more precautionary and adaptive approaches to environmental management, which emphasize the need to consider uncertainty, unpredictability, and the precautionary principle when making decisions about environmental risks (Shrader-Frechette & Westra, 1997).

In conclusion, Environmental Impact Assessment and Environmental Risk Assessment are critical tools in modern environmental management, enabling policymakers, businesses, and communities to understand, evaluate, and mitigate the potential effects of human activities on the environment. While they share common goals, the approaches of EIA and ERA differ in their scope and methodology. EIA focuses on assessing the impacts of specific projects, while ERA evaluates the likelihood and severity of potential environmental hazards. Together, these tools provide essential guidance for managing the complex environmental challenges of the 21st century, from climate change to biodiversity loss, and ensure that sustainable development can be achieved without compromising the health of the planet and its ecosystems.

Difference between Environmental Risk Assessment and Environmental Impact Assessment

The major differences between environmental impact assessment and environmental risk assessment includes the following: While environmental impact assessment is a broad field that includes all activities that attempt to analyze and evaluate the effects of human and related actions on the environment, risk assessment are generally concerned with the relatively welldefined regulatory problems and employs formal quantitative analysis of the potential risk.

2.0 STEPS/METHODS AND SIGNIFICANCE OF ENVIRONMENTAL IMPACT ASSESSMENT

2.1 Steps /Methods of Environmental Impact Assessment

Environmental impact assessment Methodology:

Whenever a new development project is planned which is likely to affect environmental quality, it is necessary to carry out EIA studies. The methodology that is typically followed for a standard EIA study involves the following:

1. The first step in EIA technique is to determine whether the project under consideration follows the jurisdiction of the relevant acts and regulations and if so, whether it is likely to create a significant environmental disruption.
2. If so, an EIA is undertaken and the environmental impact statement (EIS) is prepared.
3. In many countries, EIS is open to public scrutiny and is reviewed at public hearings.
4. Finally, a political decision is taken. The development project may be (i) accepted or (ii) accepted with amendments or (iii) an alternative proposal is accepted or (iv) rejected.

Environment Impact Assessment Process

In EIA system, there is a sequence of activities implemented in a project in logical manner termed as the EIA process.

Environmental impact assessment Process in Sequence of Application:

1. Stakeholder's Involvement:

Stakeholders‘ involvement occurs in various stages of EIA to ensure quality, efficiency and effectiveness.

2. Project Screening and Scoping:

(i) Determine necessity for EIA requirement.

(ii) Describe various screening criteria.

(iii) Scoping determines coverage or scope of EIA.

3. Project Design and Construction:

(i) Type of project under consideration.

(ii) Physical dimensions of the area being considered.

(iii) Whether the resources will be used optically?

4. Project Operation:

(i) What provisions have been made to check the safety equipment regularly?

(ii) How will the hazardous waste products be handled?

(iii) What are the contingency plans developed to cope up with the possible

5. Site Characteristics:

(i) Whether the site is susceptible to floods, earth quakes and other natural disasters?

(ii) Whether the terrain is creating problems in predicting ground water characteristics and air pollution etc.?

(iii) Whether the local environment is conductive for the success of the project?

6. Possible Environmental Impacts:

(i) What are the possible short-term and long-term environmental impacts from the projects during construction and after construction?

(ii) Who would be affected because of these impacts?

7. Mitigation Measures:

(i) Design system to avoid, reduce and minimize adverse impacts.

(ii) Enhance beneficial outcomes.

8. Monitoring and auditing measures:

(i) Identify impacts that require monitoring and auditing.

9. Socio-Economic Factors:

(i) Who are the expected gainers and losers by the projects?

(ii) Where are the expected trade-offs?

Objectives of EIA

The objectives of EIA include the following:

(i) To identify, predict and evaluate the economic, environmental and social impact of development activities

(ii) To provide information on the environmental consequences for decision making and

(iii) To promote environmentally sound and sustainable development through the identification of appropriate alternatives and mitigation measures.

2.2 Significance of the environmental impact assessment (EIA) The significance of EIA is:

1) EIA is more than technical reports, it is a means to a larger intention – the protection and improvement of the environmental quality of life.

2) EIA is a procedure to identify and evaluate the effects of activities (mainly human) on the environment - natural and social.

3.0 STEPS/METHOD AND SIGNIFICANCE OF ENVIRONMENTAL RISK ASSESSMENT 3.1 steps/method of environmental risk assessment

Five Steps to Risk Assessment

Risk assessment process is usually broken down into three separate steps: risk identification, risk analysis, and risk evaluation.

Step 1: Identify the Hazards

Identify the hazards. Walk around your environment and look at what could reasonably be expected to cause harm. Ask your other people what they think. They may have noticed things that are not immediately obvious to you. Visit the HSE website. HSE publishes practical guidance on where hazards occur and how to control them about long-term hazards to health (eg high levels of noise or exposure to harmful substances) as well as safety hazards.

Step 2: Decide who might be harmed and how

Decide who might be harmed and how For each hazard you need to be clear about who might be harmed; it will help you identify the best way of managing the risk. That doesn‘t mean listing everyone by name, but rather identifying groups of people (eg ‗people working in the storeroom‘ or ‗passers-by‘). Remember: some workers have particular requirements, eg new and young workers , migrant workers , new or expectant mothers and people with disabilities may be at particular risk.

Step 3: Evaluate the risks and decide on precautions

Evaluate the risks and decide on precautions. Having spotted the hazards, you then have to decide what to do about them. The law requires you to do everything ‗reasonably practicable‘ to protect people from harm. You can work this out for yourself, but the easiest way is to compare what you are doing with good practice

Step 4: Record your findings and implement them

Record your findings and implement them. Putting the results of your risk assessment into practice will make a difference when looking after people and your fundraising event. Writing down the results of your risk assessment, and sharing them, encourages you to do this. When writing down your results, keep it simple, for example ‗Tripping over rubbish: bins provided, staff instructed, weekly housekeeping checks‘ **Step 5: Review your risk assessment and update**

Review your risk assessment and update if necessary. Things are likely to change between first conducting your risk assessment and your fundraising event. It makes sense therefore, to review what you are doing on an ongoing basis.

Classification of Environmental Risk Assessment

Environmental risk assessments typically fall into one of two:

a. Human Health Assessment

b. Ecological Assessment

Human Health Assessment

General human health There are many resources that provide human health risk information:

The National Library of Medicine provides risk assessment and regulation information tools for a varied audience. (Risk assessment and regulation information from NLM 2013). These include:

- TOXNET (databases on toxicology, hazardous chemicals, environmental health, and toxic releases 2013),
- the Household Products Database (potential health effects of chemicals in over 10,000 common household products), (Household products Database 2013)
- TOXMAP (maps of the U.S. Environmental Protection Agency Superfund and Toxics Release Inventory data).

The United States Environmental Protection Agency provides basic information about environmental health risk assessments for the public for a wide variety of possible environmental exposures (Risk Assessment portal, EPA 2013)

The Environmental Protection Agency began actively using risk assessment methods to protect drinking water in the United States after the passage of the Safe Drinking Water Act of 1974. The law required the National Academy of Sciences to conduct a study on drinking water issues, and in its report, the NAS described some methodologies for doing risk assessments for chemicals that were suspected carcinogens, recommendations that top EPA officials have described as perhaps the study's most important part, (EPA Alumni association: senior EPA officials discuss early implementation of drinking water act of 1974).

Considering the increase in junk food and its toxicity, FDA required in 1973 that cancer-causing compounds must not be present in meat at concentrations that would cause a cancer risk greater than 1 in a million over a lifetime. The US Environmental Protection Agency provides extensive information about ecological and environmental risk assessments for the public via its risk assessment portal (Risk assessment EPA, 2013.) The Stockholm Convention on persistent organic pollutants (POPs) supports a qualitative risk framework for public health protection from chemicals that display environmental and biological persistence, bioaccumulation, toxicity (PBT) and long range transport; most global chemicals that meet this criteria have been previously assessed quantitatively by national and international health agencies (szabo and Loccisano, 2012).

For non-cancer health effects, the terms reference dose (RfD) or reference concentration (RfC) are used to describe the safe level of exposure in a dichotomous fashion. Newer ways of communicating the risk is the probabilistic risk assessment (Nielsen etal 2023).

Even a human health risk assessment starts with a good plan. Before anything though there is a need to make judgments early when planning major risk assessments regarding the purpose, scope, and technical approaches that will be used. Typically risk assessors will ask the following questions:

1. Who/What/Where is at risk? o Individual o

General population

- o Life stages such as children, teenagers, pregnant/nursing women
- o Population subgroups - highly susceptible (for example, due to asthma, genetics, etc.) and/or highly exposed (for example, based on geographic area, gender, racial or ethnic group, or economic status)

2. What is the environmental hazard of concern? o Chemicals (single

or multiple/cumulative risk) o Radiation o Physical (dust, heat) o

Microbiological or biological

- o Nutritional (for example, diet, fitness, or metabolic state)
- o Socio-Economic (for example, access to health care)

3. Where do these environmental hazards come from?

- o Point sources (for example, smoke or water discharge from a factory; contamination from a Superfund site)
- o Non-point sources (for example, automobile exhaust; agricultural runoff) o Natural sources

4. How does exposure occur?

o Pathways (recognizing that one or more may be involved)

- ▪ Air
- ▪ Surface Water
- ▪ Groundwater
- ▪ Soil
- ▪ Solid Waste
- ▪ Food

 Non-food consumer products, pharmaceuticals

Steps usually taken for Human Health Assessment

Step 1: Hazard identification:

Hazard identification is the first step of a human health risk assessment. Hazard Identification is the process of determining whether exposure to a stressor can cause an increase in the incidence of specific adverse health effects (e.g., cancer, birth defects). It is also whether the adverse health effect is likely to occur in humans. The objective of Step 1 is to identify the types of adverse health effects that can be caused by exposure to some agent in question, and to characterize the quality and weight of evidence supporting this identification.

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Key Components of Hazard Identification
A wide variety of studies and analysis are used to support a hazard identification analysis. These studies include the following:
i. Toxicokinetics
ii. Toxicodynamics

Step 2: Dose-response assessment
Dose-response assessment is the second step of a human health risk assessment. A dose-response relationship describes how the likelihood and severity of adverse health effects (the responses) are related to the amount and condition of exposure to an agent (the dose provided). Although this webpage refers to the "dose-response‖ relationship, the same principles generally apply for studies where the exposure is to a concentration of the agent (e.g., airborne concentrations applied in inhalation exposure studies), and the resulting information is referred to as the "concentration-response" relationship.

Step 3: Exposure Assessment
Exposure assessment is the process of measuring or estimating the magnitude, frequency, and duration of human exposure to an agent in the environment, or estimating future exposures for an agent that has not yet been released. An exposure assessment includes some discussion of the size, nature, and types of human populations exposed to the agent, as well as discussion of the uncertainties in the above information.

Different Kinds of Doses. Exposure assessment considers both the exposure pathway (the course an agent takes from its source to the person(s) being contacted) as well as the exposure route (means of entry of the agent into the body). The exposure route is generally further described as intake (taken in through a body opening, e.g. as eating, drinking, or inhaling) or uptake (absorption through tissues, e.g. through the skin or eye).

Range of Exposure. For any specific agent or site, there is a range of exposures actually experienced by individuals. Some individuals may have a high degree of contact for an extended period (e.g. factory workers exposed to an agent on the job). Other individuals may have a lower degree of contact for a shorter period (e.g. exposure assessment requires consideration of a range of possible exposure levels. individuals using a recreational site downwind of the factory). EPA policy for exposure assessment requires consideration of a range of possible exposure levels.

Two common scenarios for possible exposure are "Central Tendency" and "High End". "Central Tendency" exposure is an estimate of the average experienced by the affected population, based on the amount of agent present in the environment and the frequency and duration of exposure.

"High End" exposure is the highest dose estimated to be experienced by some individuals, commonly stated as approximately equal to the 90th percentile exposure category for individuals.

Quantifying Exposure. There are three basic approaches for quantifying exposure. Each approach is based on different data, and has different strengths and weaknesses; using the approaches in combination can greatly strengthen the credibility of an exposure risk assessment.

- **Point of Contact Measurement** **Scenario Evaluation** **Reconstruction -**

Step 4: Risk characterization

Risk characterization is the last step of a human health risk assessment. A risk characterization conveys the risk assessor's judgment as to the nature and presence or absence of risks, along with information about how the risk was assessed, where assumptions and uncertainties still exist, and where policy choices will need to be made. Risk characterization takes place in both human health risk assessments and ecological risk assessments.

2. Ecological Risk Assessment

Even an ecological risk assessment starts with a good plan. Before anything though there is a need to make judgments early when planning major risk assessments regarding the purpose, scope, and technical approaches that will be used. To start, risk assessors will typically ask the following questions:

1. Who/What/Where is at risk? o Individual o

General population

- Life stages such as juveniles or adults
- Population subgroups — highly susceptible (for example, due to genetics) and/or highly exposed (for example, based on geographic area)
- Different species — mink, for example, are highly susceptible to PCBs

2. What is the environmental hazard of concern? o Chemicals

(single or multiple/cumulative risk) o Radiation

- Physical (changes to a habitat)
- Microbiological or biological (disease or invasive species)
- Nutritional (for example, fitness or metabolic state

3. Where do these environmental hazards come from?

- Point sources (for example, smoke or water discharge from a factory; contamination from a Superfund site)
- Non-point sources (for example, automobile exhaust; agricultural runoff)
- Natural sources

4. How does exposure occur? o Pathways (recognizing that one or more may be involved)

- Air
- Surface Water
- Groundwater
- Soil
- Solid Waste
- Food

Phases of Ecological Risk Assessment

The different phases of the ecological risk assessment process include the problem formulation, analysis, risk characterization and risk management as shown in figure below.

Phase 1: Problem Formulation

The objective of the problem formulation phase is to define an assessment endpoint to determine what ecological entity is important to protect. An ecological entity can be:

- A species (for instance: piping plover)
- A functional group of species (for instance: piscivores - i.e., fish eaters)
- A community (for instance: benthic invertebrates)
- An ecosystem (for instance: lake)
- A specific valued habitat (for instance: wet meadows)
- Another entity of concern

Phase 2: Analysis

The objective of the analysis phase is to provide the ingredients necessary for determining or predicting ecological responses to stressors under exposure conditions of interest.

Analysis is the determination of what plants and animals are exposed and to what degree they are exposed and if that level of exposure is likely or not to cause harmful ecological effects. Calculations used may include:

1. **Hazardquotients**
2. **variousparameters**
3. **Areause**
4. **Foodingestionrate**
5. **Bioaccumulationrates**
6. **Bioavailability**
7. **Life stage**

Phase 3: Risk Characterization

The objective of the risk characterization phase is to use the results of analysis to estimate the risk posed to ecological entities. The assessor then describes the risk, indicating the overall degree of confidence in the risk estimates, summarizing uncertainties, citing evidence supporting the risk estimates, and interpreting the adversity of ecological effects.

3.2 Significance of Environmental Risk Assessment significance of environmental risk assessment

The risk assessment establishes levels of contaminants that can remain at a site and still be adequately protective of public health. The risk assessment provides a consistent process for evaluating and documenting public health hazards associated with exposure to environmental contamination.

4.0 CASE HISTORIES 4.1 Case History: Environmental Impact Assessment In Nigeria: Regualatory Background And Procedural Framework

(environmental impact assessment in nigeria: regulatory background and procedural framework Nerry echefu and.E. Akpofure, 2002)

As a consequence of the illegal dumping of toxic wastes in Koko, in the former Bendel State, in 1987, the Nigerian Government promulgated the Harmful Wastes Decree which provides the legal framework for the effective control of the disposal of toxic and hazardous waste into any environment within the confines of Nigeria. This was immediately followed by the creation of a regulatory body, the Federal Environmental Protection Agency (FEPA) in 1988. FEPA is charged with the overall responsibility of protecting and developing the Nigerian environment. To put this into action a National Policy on the Environment was developed. This is the main working document for the preservation and protection of the Nigerian environment. States and Local Government Councils were also encouraged to establish their own environmental regulatory bodies for the purpose of maintaining good environmental quality as it applies to their particular terrain. The EIA Decree No. 86 of 1992 is an additional document with the same aim of protecting the Nigerian environment. It is particularly directed at regulating the industrialization process with due regard to the environment. By this Decree, no industrial plan/development/activity falling under the FEPA's mandatory list can be executed without prior consideration of the environmental consequences of such a proposed action, in the form of an environmental impact assessment. The Department of Petroleum Resources (DPR), an arm of the Ministry of Petroleum Resources, recognizing the national importance of the oil and gas industry sector to the continued growth of the Nigerian economy and realizing that the continued exploitation, exploration and production of the oil resources has serious environmental impacts, also decided to set out comprehensive standards and guidelines to direct the execution of projects with proper consideration for the environment.

There is duplication of functions and overlapping responsibilities in the processes and procedures guiding the execution of the various impact assessment tasks. Consequently, serious bottlenecks and bureaucratic confusion are created in the process. The result is a waste of resources, financially and materially. This paper examines the statutory regulatory framework for the EIA process, and the inadequacies and misinterpretations of the various statutes, which have often led to delays in the execution of EIAs in Nigeria. An attempt will be made to streamline these various responsibilities through a reorganization of the regulatory environmental framework. This way, it is hoped that the bottlenecks and wastage of resources will be eliminated.

INSTITUTIONAL AND REGULATORY FRAMEWORK

Prior to the establishment of the FEPA there were sectoral environmental regulations with various significant responsibilities relating to environmental protection and improvement. Also in existence were commissions with advisory capacity in environmental matters and environmental NGOs. Due to various activities and the complex combination of interdependent operations of the oil industry it, more than any other sector, adversely affects the environment. In the oil industry DPR adopted remedial, though inadequate, enforcement tools which included compliance monitoring and the issuing of permits/licences. Studies indicated the extent of devastation the oil industry has caused to aquatic and terrestrial ecosystems and cultural and historical resources. This, coupled with the community's dissatisfaction and agitation, especially in the Ogoni and Ijaw homelands, reinforced the need for the sector to plan, protect and enhance prudently the environmental resources for a better environment, the need to control new installations or projects with capacity to degrade the environment was also identified. This compelled DPR to issue updated Environmental Guidelines and Standards (EGAS) in 1991 providing for the first time, together with pollution abatement technology, guidelines and standards and monitoring procedures, a mandatory EIA report as enforcement tool. There are other regulatory bodies within the sector. FEPA, charged with the protection and development of the environment, prepared a comprehensive national policy, including procedures for environmental impact assessment for, amongst others, all development projects. Enforcement powers were also prescribed. In the National Policy on the Environment (NPE), FEPA adopted a strategy that guarantees an integrated holistic and systemic view of environmental issues that leads to prior environmental assessment of proposed activities. The other regulators including State EPAs (unnecessarily charged with similar and identical responsibilities to those of FEPA) rather than cooperating with FEDA undermine its efforts as they demand a role in the state of the environment within their areas. This occurs particularly where FEPA involves them only at the review stage in the EIA process. This creates a lot of confusion and bureaucratic delays in implementing the EIA process leading to enormous cost and unnecessary waste of time.

ENVIRONMENTAL IMPACT ASSESSMENT SYSTEM

Features The principal legislation is Decree 86 of 1992 which made EIA mandatory for both public and private sectors for all development projects. It has three goals and thirteen principles for how these are to be achieved. The goals are: • Before any person or authority takes a decision to undertake or authorize the undertaking of any activity that may likely or significantly affect the environment, prior consideration of its environmental effects should first be taken. • To promote the implementation of appropriate procedures to realize the above goal. • To seek the encouragement of the development of reciprocal procedures for notification, information exchange and consultation in activities likely to have significant trans-state (boundary) environmental effects. FEPA categorizes mandatory study activities into three categories. (see Figure 1 below): Category 3 activities have beneficial impacts on the environment. For Category 2 activities (unless within the Environmentally Sensitive Area) full EIA is not mandatory, while Category 1 activities require full and mandatory EIA. Either listing or an initial environmental evaluation (IEE) system is used to determine projects requiring full EIA

PROCESS AND PROCEDURAL FRAMEWORK

The EIA process is the various stages a project undergoes from proposal to approval for implementation, resulting in the issuing of an Environmental Impact Statement (EIS) and certificate. The term encompasses several stages, viz: • determining if FEPA environmental laws/regulations have been triggered; • screening a project for potential environmental effects; • scoping to determine the spatial and temporary dimension of environmental effects; • carrying out detailed base line studies to determine the environmental condition prior to project implementation; • preparing a detailed assessment report; • carrying out a panel review of the EIA report if this is necessary; and • obtaining authorization/approval, where appropriate. For FEPA, the Director General/Chief Executive is the responsible officer. The National Procedural Guidelines show practical steps from project conception to commissioning (see Figure 2). The steps are: • project proposal • initial environmental examination (IEE)/preliminary assessment • screening • scoping • EIA study • review • decision making • monitoring, and • auditing. The proponent initiates the process in writing to the responsible officer. A notification form is duly completed with all relevant information on the proposal. Using the criteria of : • magnitude – probable severity of each potential impact; • prevalence/extent and scope – extent to which the impact may eventually extend; • duration and frequency – is activity short term, long term or intermittent; • risks – probability of serious environmental effects; • significance/importance – value attached to a specified area; and • mitigation – measures available for associated and potential environmental effects FEPA does internal screening (IEE) to determine the project‘s category under the mandatory study activities list. Where no adverse environmental effects exist, the EIA is issued and the project commences with appropriate mitigation and monitoring measures. Otherwise within ten working days of receipt of the proposal, the screening report is sent to the proponent for scoping and the preparation of Terms of Reference (ToR). The ToR embodies the scope of the proposed EIA study and this is examined and the scope of the study defined accordingly by FEPA. The

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proponent carries out the study, generally using consultants, and the draft EIA report in 15 copies is submitted to the responsible officer. For this draft report to be complete it must as an annex record the results of public participation in a public form. Within 15 working days of the receipt of the draft report, FEPA concludes evaluation of the draft and determination of the review method which it communicates to the proponent in writing. The four methods are: • In-house review. • Panel review (sitting may be public). • Public review – an elaborate display of the report for 21 working days with appropriate display venues chosen by FEPA for the convenience of the public stakeholders and communities. Through newspaper advertisement FEPA invites interested groups /persons to participate. • Mediation. Within one month of the review process, review comments are furnished to the proponent. In this review stage, the public participates only when FEPA‘s chosen method of review guarantees its participation. The final EIA report, addressing and proffering answers to review comments, is submitted within six months to the responsible officer. At this early stage, and on mutual agreement, FEPA and the proponent seconditions establishing a follow-up program (mitigation, compliance and monitoring plan), a monitoring strategy and audit procedure.

4.2 CASE HISTORY: Environmental risk assessment in selected dumpsites in Abakaliki metropolis, Ebonyi state, southeastern Nigeria

(Daniel Aja et al 2021 environmental risk assessment in selected dumpsites in abakiliki metropolis, ebonyi state southeasthern Nigeria)

Presently, the magnitude of soil pollution at global scale is increasing significantly due to rapid rate of industrialization, increase in population growth and urbanization (UNIDO, 2011). Accordingly, the increment in waste load has led to environmental pollution and degradation in many cities of the world. Most African countries including Nigeria are dumping ground for electronic and other hazardous wastes containing lead, cadmium, mercury, cobalt, arsenic and other toxic metals. These metals in the soil affect the health of living organisms and natural environment (Zurbrug, 2003; Amadi et al., 2010; Okolo et al., 2013a) especially when the concentrations are above certain threshold (Udeigwe et al., 2015). Furthermore, small and largescale industries located in urban areas often dispose their wastes along with municipal solid wastes, which is a serious threat to the entire ecosystem (Dongballe, 2016).

Potential contamination of soil by heavy metal may occur as a result of leaching from industrial processes and other anthropogenic activities including indiscriminate disposal of e-wastes, excessive application of fertilizer and animal manure or sewage to the soil, waste-water irrigation, atmospheric deposition, crude oil and petrochemical spillage (Khan et al., 2008; Zhang et al., 2010; Okolo et al., 2013a). Metal buildup in soils and sediments has serious environmental risks because of its harmful effect to both terrestrial (Tang et al., 2014) and aquatic ecosystem, including the underground aquifer (Igwe and Chukwura, 2018). However, the availability of heavy metals for plant uptake in the soil depends on soil pH, clay content and organic matter amongst other factors (Molla and Huq, 2002, 2004). Anions such as nitrate (NO_3^-), sulphate (SO_4^{2-}) and phosphate (PO_4^{3-}) are important sources of nutrients for plant growth and are required for synthesis of different compounds essential for all living organisms (Chinyere et al., 2013), but can be inhibited by the presence of heavy metals in the soil.

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The study area

This study was conducted in Abakaliki Metropolis, Ebonyi state, South-eastern Nigeria. The area lies within Latitude 06°04′N and Longitude 08° 65′E in the derived savannah zone of South-East Nigeria. Three dumpsites were used for the study: New layout dumpsite (NLD) 6° 19′ 42.66″ N, 8° 06′ 55. 78″ E; Azuiyiokwu dumpsite (AD) 6° 18′ 44.90″ N, 8° 05′ 55.26″ E; and Mechanic village dumpsite (MVD) 6° 18′ 58.62 N, 8° 07′ 42.52″ E (Fig. 1).

Abakaliki has a land area of about 5670 square kilometers with an estimated population of 141, 438 (NPC, 2006). The inhabitants of Abakaliki predominantly lead agrarian life and generate mainly household wastes with a mixture of e-wastes. The area is associated with relatively high temperature range (27 °C-31 °C). The rainfall pattern is bimodal (April–July) and (September– November) with an August break (Mbah et al., 2017). The relative humidity range is 60–80% for minimum and maximum. The soil of the area is dominated by Nitisols (NT) (Fig. 2) which represents the hydrological soil group ―*C*‖ and it is described as Silt Loam or Sandy Clay Loam with high relative run-off potential (Aja et al., 2019).

Soil sampling

Soil sampling was carried out during the dry season of 2019 (between October and December).

The sampling points (Mechanic Village Dumpsite (MVD), Azuiyiokwu Dumpsite (AD) and New-layout Dumpsite (NLD)) were cleared of waste before sample collection. Soil samples were collected at 0–15 cm and 15–30 cm soil depth in each dumpsite. A total of thirty-six (36) samples were collected using handheld auger. The soil samples were arranged separately according to the method of Hodgson (1993). Auger samples were air dried, crushed, sieved with 2 mm sieve, and transported to the Lagos State Environmental protection Agency (LASEPA) Laboratory for analysis in black polyethylene bags.

Determination of heavy metals and anions

Heavy metals were determined by the Aqua Regia method as modified by Salt (1998). Air- dried and previously sieved soil samples were weighed to obtain 0.5 g and this quantity was digested with concentrated nitric acid (HNO_3) and filtered through ash-less filter paper. The clear digest was diluted in a 50 ml acid cleaned standard flask with distilled water up to the required mark. Atomic Absorption Spectrometer (AAS) (Shimadzu double beam AA-6300 and Perkin Elmer Aanalyst 400) was used to analyze the amount of lead (Pb), cadmium (Cd), Copper (Cu), Zinc (Zn) and Iron (Fe) in the sample solutions.

For sulphate and nitrate, 10 g of the soil sample was weighed into a 50 ml centrifuge tube and 25 ml of distilled water was added. The solution was stirred occasionally for 30 min with a glass rod on an orbital shaker. The solution was filtered using filter paper. Pilos of sulphate and nitrate were added to the clear filtrate. The samples were then taken to spectrophotometer for detection and reading. For phosphate (PO_4^{3-}), the method used was the same as the one described above for sulphate and nitrate. However, 10 ml of distilled water was added and phosphate pilos were added in contrast to what was added for sulphate and nitrates.

Contamination levels assessment

Several contamination indicators such as factor of contamination (C_f), factor of enrichment (E_f), geo-accumulation index (I_{geo}), environmental risk index (R_i) and modified environmental risk index (MR_i) as described by Keshavarzi and Kumar (2020); and Kumar et al. (2018) were used to evaluate the degree of pollution and the level of environmental risks posed by heavy metals leaching in the selected dumpsites.

2.5.1. Contamination factor (C_f)

The contamination factor indicates the artificial inputs of heavy metals in the dumpsite (Ahmed et al., 2016). It is given by the following equation:(1)Cf=HMsHMcWhere,

HM_s is the concentrations of heavy metals in sampling sites and HM_c is the concentrations of heavy metals in reference. The contamination factor (C_f) is categorized into four viz: low contamination ($C_f < 1$)); moderate contamination ($1 < C_f \leq 3$); high contamination ($3 < C_f \leq 6$) and very high contamination ($C_f > 6$) (Hakanson, 1980). The global mean concentrations of metals in the soil as reported by Turekian and Wedepohl (1961) were used as control in this study because country specific background measurements for these elements are not available.

Environmental risk assessment (RI and MRI)

The environmental risk index (R_I) was computed to estimate the potential environmental risk of heavy metals from the dumpsites. The index is given by the product of the contamination factor (C_f) of each metal and the toxicological response factor (Tr) of individual metal (Kumar et al., 2018). It is expressed by the following equation:(4)RI=CFn×TrWhere

CF_n and T_r are the contamination factor and toxicological response for individual metal. The toxicological response (Tr) has a value of 1 for Zn; 5 for Pb and Cu; 30 for Cd (Manoj and Padhy, 2014). Environmental risk index (R_I) is categorized into five groups viz: low risk ($R_I <$ 30), moderate risk (R_I: 30–60), considerable risk (R_I: 60–120), high risk (R_I: 120–240), significantly high risk ($R_I > 240$).

To compute the modified ecological risks index (MR_I) which is essentially as a result of anthropogenic additions of metals in dumpsites, the factor of contamination (C_f) is replaced by factor of enrichment (E_f) in Eq. (4) above (Kumar et al., 2018).(5)MRI=Efn×TrWhere:

E_{fn} and T_r are the factor of enrichment and toxicological response of individual heavy metals. The ranking for risk assessment is as follows: low risk ($MR_I < 40$), moderate risk (40–80), considerable risk (80–160), high risk (160–320), and very high risk (>320).

Results

Descriptive statistics of heavy metals and anions

Tables 1 and 2 showed the results of heavy metal concentration across the three dumpsites. The concentrations of Pb ranged from 12.90 to 19.51 $mgkg^{-1}$ at 0–15 cm depth. The highest concentration (19.51 $mgkg^{-1}$) of Pb was recorded at MVD and the lowest concentration (12.90 $mgkg^{-1}$) was found NLD. The concentration of lead at AD was found to be 18.72 $mgkg^{-1}$. Concentrations of Cd ranged from 0.01 to 0.14 $mgkg^{-1}$ in 0–15 cm soil depth.

Azuiyiokwu dumpsite had the highest concentration (0.14 $mgkg^{-1}$) followed by MVD which had 0.10 $mgkg^{-1}$ (Tables 1 and 2). The least concentration was found at NLD (0.01 $mgkg^{-1}$). The sub-soil (15–30 cm) concentrations of Cd ranged from 0.03 to 0.12 $mgkg^{-1}$. The lowest concentration was obtained at MVD (0.03 $mgkg^{-1}$).

Sites	**Pb**	**Cd**	**Cu**	**Zn**	**Fe**	**PO43–**	**NO3–**	**SO42–**
MVD	19.51	0.10	56.26	84.21	280.16	0.10	11.90	4.00
AD	18.72	0.14	16.41	42.21	84.13	2.31	2.70	29.01
NLD	12.90	0.11	10.35	63.96	26.42	0.55	16.30	4.90
Mean	17.04	0.12	27.67	63.46	130.24	0.99	10.30	12.64
Std Deviation	3.61	0.02	24.94	21.00	133.01	1.17	6.94	14.19
Sample Variance	13.03	0.00	622.08	441.19	17,690.37	1.36	48.16	201.27
Skewness	−1.64	1.29	1.62	−0.11	1.37	1.45	−0.98	1.72
Range	6.61	0.04	45.91	42.00	253.74	2.21	13.60	25.01
Minimum	12.90	0.10	10.35	42.21	26.42	0.10	2.70	4.00
Maximum	19.51	0.14	56.26	84.21	280.16	2.31	16.30	29.01
Sum	51.13	0.35	83.02	190.38	390.71	2.96	30.90	37.91

Count	3	3	3	3	3	3	3	3

MVD:MechanicVillageDumpsite.AD:Azuiyiokwudump site.
NLD: New Layout Dumpsite. Table 2. 15–30 cm depth.

Descriptive Statistics of Heavy Metals and Anion Concentrations (mgkg^{-1}) at

Table 1. Descriptive Statistics of Heavy Metals and Anion Concentrations (mgkg^{-1}) at 0–15 cm depth.

Sites	**Pb**	**Cd**	**Cu**	**Zn**	**Fe**	**PO_4^{3-}**	**NO_3^-**	**SO_4^{2-}**
MVD	4.71	0.03	21.31	11.2	250.36	2.72	12.3	9
Sites	**Pb**	**Cd**	**Cu**	**Zn**	**Fe**	**PO_4^{3-}**	**NO_3^-**	**SO_4^{2-}**
AD	9.53	0.12	1.38	45.38	20.11	2.39	1.5	39
NLD	4.40	0.05	2.18	10.32	12.18	0.59	20.3	58
Mean	6.21	0.07	8.29	22.30	94.22	1.90	11.37	35.33
Std Deviation	2.88	0.05	11.28	19.99	135.28	1.15	9.43	24.70
Sample Variance	8.28	0.00	127.30	399.71	18,301.28	1.31	89.01	610.33
Skewness	1.71	1.39	1.72	1.73	1.73	−1.57	−0.44	−0.65
Range	5.13	0.09	19.93	35.06	238.18	2.13	18.80	49.00
Minimum	4.40	0.03	1.38	10.32	12.18	0.59	1.50	9.00
Maximum	9.53	0.12	21.31	45.38	250.36	2.72	20.30	58.00
Sum	18.64	0.20	24.87	66.90	282.65	5.70	34.10	106.00

3 3 3 3 3 3 3 3

Count
MVD: Mechanic Village Dumpsite.
AD: Azuiyiokwu dumpsite.
NLD: New Layout Dumpsite.

Tables 1 and 2 showed that the concentration of Cu ranged from 10.35 to 56.26 $mgkg^{-1}$ in the surface (0–15 cm) soil samples. The highest concentration of 56.26 $mgkg^{-1}$ was obtained at the MVD. The concentration of Cu obtained at AD was 16.41 $mgkg^{-1}$. At the depth of 15–30 cm, the concentrations of Cu across the dumpsites ranged from 1.38 to 21.31 $mgkg^{-1}$. MVD again had the highest concentration (21.31 $mgkg^{-1}$). The concentration of Zn as presented in Tables 1 and 2 showed that surface (0–15 cm) soil samples had the highest Zn concentration compared to the subsoil (15–30 cm) samples. The concentrations of Zn in surface soil ranged from 21.32 to 84.21 $mgkg^{-1}$. The highest concentration of Zn (84.21 $mgkg^{-1}$) was found at MVD while the lowest concentration of 21.32 $mgkg^{-1}$ was obtained at NLD. Within 15–30 cm depth, the concentration of Zn ranged from 10.32 to 45.38 $mgkg^{-1}$ which is lower than the topsoil Zn concentration (21.32–84.21 $mgkg^{-1}$).

Tables 1 and 2 indicated that Fe had the highest concentrations in all the three dumpsites. The topsoil (0–15 cm) had the highest concentrations of Fe compared to the sub-soil (15–30 cm). The concentration of Fe in the topsoil (0–15 cm) ranged from 26.42 to 280.16 $mgkg^{-1}$ across the dumpsites. Mechanic village dumpsite had the highest Fe concentration of
280.16$mgkg^{-1}$ followed by AD (84.13$mgkg^{-1}$) and NLD with the lowest concentration of 26.42 $mgkg^{-1}$**.** At 15–30 cm depth, the concentrations of Fe ranged from 12.18 to 250.36$mgkg^{-1}$. Mechanic village dumpsite again had the highest concentration (250.36 $mgkg^{-1}$) followed by AD that had 84.13 $mgkg^{-1}$. The lowest concentration was obtained at NLD (12.18 $mgkg^{-1}$). The concentration of phosphate (PO_4^{3-}) obtained at AD within the depth of 0–15 cm was
2.3 $mgkg^{-1}$ (Table 2; Fig. 3). Mechanic village dumpsite had 0.1 $mgkg^{-1}$ while NLD had 0.55 $mgkg^{-1}$ within the depth of 0–15 cm. At the depth of 15–30 cm, the amount of PO_4^{3-} obtained at AD was 2.39 $mgkg^{-1}$ while NLD and MVD had 0.59 $mgkg^{-1}$ and 2.72 $mgkg^{-1}$, respectively. Our result showed that Nitrate (NO_3^-) and Sulphate (SO_4^{2-}) followed the same trend with that of PO_4^{3-} across the three dumpsites investigated.

Contamination levels assessment

The contamination level assessment was done by implementing Eqs. (1)–(5) and the results are presented in Tables 5–7 below.

Table 5. Contamination level assessment at Mechanic village dumpsite.

Heavy metal	C_f	E_f	Igeo	RI	MRI
Pb	4.71	1880	0.80	22	9400
Cd	0.60	20	0.12	18	600
Cu	2.03	850	0.43	10	4250
Zn	0.2	90	0.05	0.2	90
Fe	2×10^{-5}	1	2×10^{-3}	–	–

Table 6. Contamination level assessment at Azuiyiokwu dumpsite.

Heavy metal	C_f	E_f	I_{geo}	RI	MRI
Pb	9.5	3800	1.91	48	19,000
Cd	2.4	800	0.48	72	24,000
Heavy metal	**C_f**	**E_f**	**Igeo**	**RI**	**MRI**
Cu	0.14	55	0.03	0.7	275
Zn	0.9	362	0.18	0.9	362

Fn	2×10^{-5}	1	4×10^{-5}	–	–

Table 7. Contamination level assessment alayout New-t dumpsite.

Heavy metal	**C_f**	**E_f**	**I_{geo}**	**RI**	**MRI**
Pb	4.4	176	0.90	22	880
Cd	1	400	0.70	30	12,000
Cu	0.2	22	0.04	1	110
Zn	0.2	82	0.04	0.2	82
Fe	1×10^{-5}	1	5×10^{-4}	–	–

Discussion

Descriptive statistics

The results of metal concentrations in sub-soil (15–30 cm) samples across the studied dumpsites indicated that the concentrations of lead (Pb) were 4.40 mgkg^{-1}, 4.71 mgkg^{-1} and 9.53 mgkg^{-1} for NLD, MVD and AD, respectively. The Lagos state Environmental protection Agency (LASEPA, 2005) and the world Health organization (WHO, 2006) soil quality guideline for Pb is 5.0 mgkg^{-1}. Elevated concentration of Pb was noticed in all the surface soil samples. However, the concentration of Pb in the sub-soil was found to be within the acceptable limits except for AD that had 9.5 mgkg^{-1}. This agrees with the result of Esakku et al. (2014) which showed higher concentrations of Pb within 1–2 m depth in various dumpsites in India. Okolo et al. (2013b) and Olowookere et al. (2018) reported similar trend in different parts of Nigeria.

The concentrations of Cd found at AD and MVD at 0–15 cm were 14 and 10 times higher than the WHO permissible limit (0.01 mgkg^{-1}) while Cd concentration found at NLD was within the permissible limit. The sub-soil (15–30 cm) concentrations of Cd ranged from 0.03 to 0.12 mgkg^{-1}. The lowest concentration was obtained at MVD (0.03 mgkg^{-1}) and is 3 times higher than the WHO permissible limit while the highest concentration (0.12 mgkg^{-1}) was found at AD and it's 12 times higher than the WHO permissible limit. These values were above the recommended concentrations limit of 0.01 $mgkg^{-1}$ by World Health organization (WHO, 2006) but below the recommended limit by the Lagos State Environmental Protection Agency (0.2 $mgkg^{-1}$) (LASEPA, 2005). This implies that cadmium concentrations were within the acceptable limits across the studied dumpsite with regards to LASEPA (2005) standard. Similarly, the concentrations of arsenic, mercury and cadmium found by Esakku et al. (2014) at various dumpsites in India were comparatively less than that obtained for the other metals. Nevertheless, even though the concentrations of Cd at NLD is within the WHO and LASEPA permissible limits, it should be noted that heavy metal contamination even if in traces or small quantities are serious environmental concern as these metals can be readily transported and with high chances of persisting within the ecosystem for a long period of time thereby increasing their concentrations over time (Okolo et al., 2018).

The highest concentration (10.35 $mgkg^{-1}$) of Cu was found at NLD. The concentrations of Cu found at MVD, AD and NLD at 0–15 cm were 1.8, 6.0 and 9.6 times lower than the WHO permissible limit (100 $mgkg^{-1}$), respectively. The Cu concentration at NLD was found to be 2.18 $mgkg^{-1}$ while the least concentration of 1.38 $mgkg^{-1}$ was found at AD. The concentrations of Cu recorded at MVD at 15–30 cm (21.31 $mgkg^{-1}$) was about 5 times lower than WHO permissible limit while the concentrations found at AD and NLD at 15–30 cm were 72 and 46 times lower than the WHO permissible limit (100 $mgkg^{-1}$), respectively. Considering the established guidelines, toxic levels were not observed for Cu at MVD, AD and NLD within the depth of 0–30 cm. The elevated concentration of heavy metals at the topsoil (0 −15 cm) relative to the sub soil (15–30 cm) is in line with the observations of Pan et al. (2010), Okolo et al. (2013a), (2015) and Olowookere et al. (2018).

The highest concentration of Zn (84.21 $mgkg^{-1}$) was found at MVD while the lowest concentration of 21.32 $mgkg^{-1}$ was obtained at NLD. The concentration of Zn observed at AD was 48.21 $mgkg^{-1}$. In most cases, high Zn concentration tends to reduce Cu concentration (Allen, 1995) as evidenced in our study (Tables 1 and 2). In the topsoil across all dumpsites, Zn concentration increases while Cu concentration reduces.

Contamination levels and ecological risks assessment

Heavy metals loading and their ecological risks across the dumpsites were assessed using several pollution indices such as factor of contamination (C_f), factor of enrichment (E_f), geoaccumulation index (I_{geo}), environmental risk index (R_I) and modified environmental risk index (MR_I). Our result show moderate to high contamination of Cd, Cu and Pb across the studied dumpsites. We observed low enrichment of Fe across the dumpsites, high enrichment of Cu at New-layout dumpsite and exceptionally high enrichment of Pb, Cd, and Zn across the 3 dumpsites. Index of geo-accumulation indicates moderate pollution across the dumpsites except for Azuiyiokwu dumpsite where Pb appears to have high pollution index. There is low environmental risk index (RI) at Mechanic village dumpsite and New-layout dumpsite while Azuiyiokwu dumpsite recorded a moderate to considerable risk. The modified environmental risk index (MRI) showed very high risk across the studied dumpsites.

5.0 Conclusion

Environmental risk assessment and environmental impact assessment have broad definitions and significance. It has been defined and explained differently by many authors. But in all it involves the process of assessing project or health risk associated with human activities and natural hazards in the environment. Risk assessment are expected to be carried out before a project is executed, and risk assessment should be done to control health problems associated with heavy metal and hazardous chemical waste in the environment.

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