Wulayatu Mohammed

COMPARATIVE ANALYSIS OF EKOGRID TECHNOLOGY IMPLEMENTATION IN SOIL REMEDIATION PROJECTS IN CANADA AND NIGERIA

Master of Engineering

Degree programme in Project and Sales Management

2024

South-Eastern Finland University of Applied Sciences

Kaakkois-Suomen ammattikorkeakoulu

Tutkintonimike	Insinööri (YAMK)
Tekijä	Wulayatu Mohammed
Työn nimi	Vertaileva analyysi EKOGRID teknologian käyttöönotosta maaperän kunnostusprojekteissa Kanadassa ja Nigeriassa.
Toimeksiantaja	Ekogrid Oy
Vuosi	2024
Sivut	19 sivua
Työn ohjaajat	Matti Koivisto, Xamk; Tero Halmari, Ekogrid Oy

TIIVISTELMÄ

EKOGRID-teknologian soveltaminen saastuneen maaperän puhdistuksessa on saamassa suosiota kehittyneissä ja kehittyvissä maissa, mikä luo mahdollisuuksia ja haasteita. Tässä opinnäytetyössä tutkittiin projektikumppanuuksien, rakenteiden ja hallinnan dynamiikkaa EKOGRID-teknologiaan perustuvissa maaperän puhdistushankkeissa.

Tutkimus keskittyi arvioimaan EKOGRID-teknologian soveltamista Kanadassa ja Nigeriassa saastuneen maaperän puhdistuksessa, kiinnittäen erityistä huomiota puhdistushakkeiden onnistumiseen ja epäonnistumiseen vaikuttaviin tekijöihin. Painopiste oli kattavien päätelmien tekemisessä sekä riskien arvioimisessa moninaisissa liiketoimintaympäristöissä. Tavoitteena oli tarjota EKOGRID Oy:lle kattava ymmärrys sen roolista kumppanuuksien luomisessa ja projektien toteuttamisessa eri globaaleissa yhteyksissä.

Tutkimus toteutettiin kahden tapauksen tapaustutkimuksena ja sen lähdeaineistona käytettiin kirjallisia lähteitä EKOGRID-teknologian soveltamisesta kohdemaissa. Tulokset osoittivat, että tekijät, jotka vaikuttavat puhdistushankkeiden tuloksiin, eroavat merkittävästi Kanadan ja Nigerian välillä. Tämä viittaa siihen, että työn toimeksiantajan tulisi ottaa ne huomioon ennen kumppanuuden solmimista muiden yritysten kanssa maaperän puhdistuksessa. Lisäksi sen tulisi olla tietoinen teknisen osaamisen puutteesta, heikoista politiikoista, riittämättömistä varoista ja korruptiosta kehittyvissä maissa, kuten Nigeriassa on havaittu.

Avainsanat: EKOGRID-teknologia, puhdistus, säätely

South-Eastern Finland University of Applied Sciences

Degree title	Bachelor of Engineering
Author	Wulayatu Mohammed
Thesis title	Comparative Analysis of EKOGRID Technology Implementation in Soil Remediation Projects in Canada and Nigeria
Commissioned by	Ekogrid Oy
Time	2024
Pages	19 pages
Supervisors	Matti Koivisto, Xamk; Tero Halmari, Ekogrid Oy

ABSTRACT

The application of EKOGRID technology in remediating contaminated soil is gaining popularity in developed and developing countries, presenting opportunities and challenges. This thesis explores the dynamics of project partnerships, structures, and management aspects in the context of using EKOGRID technology in soil remediation projects.

The study focuses on evaluating the application of the EKOGRID technology in Canada and Nigeria in remediating contaminated soil, with a keen eye on discerning the impact of factors like weak regulations and corruption on the remediation project outcomes. Emphasis is laid on drawing comprehensive conclusions concerning the lessons learned – positive and negative – in diverse business environments. The goal is to provide EKO with a comprehensive understanding of its role in forging partnerships and undertaking projects in different global contexts.

Primarily, the study relies on a literature review from case studies and online sources about the application of EKOGRID to gather information. Results indicate that the factors impacting the remediation project outcomes differ considerably between Canada and Nigeria. This suggests that EKO Hardens Technologies should consider them before partnering with other companies for soil remediation. EKO should be mindful of the lack of technical expertise, weak policies, inadequate funds, and corruption in developing nations, as evidenced in the case of Nigeria.

Keywords: EKOGRID technology, remediation, regulation

CONTENTS

GLOSSARY

BTEX	Benzene, toluene, ethylbenzene, and xylene
BTEX	Benzene, toluene, ethylbenzene, and xylene
HYPREP	Hydrocarbon Pollution Remediation Project
IRS	Infrared Spectroscopy
LIF	Laser-induced fluorescence
MNA	Monitored Natural Attenuation
NOSDRA	National Oil Spill Detection and Response Agency
PAHs	Polyclinic aromatic hydrocarbons
TPHs	Total Petroleum Hydrocarbons
UK	United Kingdom
UNEP	United Nations Environment Programme
USA	United States of America

1 INTRODUCTION

The soil can be contaminated for many reasons, such as mining, accidental spills, improper waste disposal, military activities, and acid rain. According to a 2022 report by the European Environment Agency (EEA), contaminated soils negatively impact soil fertility, affecting food security and the survival of human beings. Because of the danger contaminated soil poses to humans and the environment, efforts have been made to remediate polluted soil. Traditional soil remediation methods have required digging and cleaning the contaminated soils. However, more cost-effective methods have been developed in recent years to clean the soil without digging the polluted soil. One of the contemporary cutting-edge technologies used in soil remediation is EKOGRID technology. This study was commissioned by EKOGRID Oy, which develops and offers various technologies for groundwater, soil, and sediment remediation under the EKOGRID technology brand.

The application of EKOGRID technology has experienced unprecedented growth in the recent past, with soil remediation projects relying on this technology to clean contaminated soils. This method involves utilizing a low-pulsed electrical current to create electrochemical and electrokinetic redox reactions to oxidize the soil. The method is applied in remediating soil contaminants such as BTEX and PAH compounds because it is sustainable and ecologically friendly.

The study aims to compare the application of EKOGRID technology in soil remediation projects in Canada and Nigeria, with a specific focus on identifying the key factors influencing the success of these projects. In addition, the thesis aims to provide tools and methods to evaluate the risks of soil remediation projects. The research questions of the thesis are:

- How do project partnership, structure, and management aspects influence soil remediation projects utilizing EKOGRID technology, and what lessons can be drawn from these aspects in business environments?

- What are the major differences in project partnership, structure, and management practices in soil remediation projects in Canada and Nigeria?
- What factors influence the success of soil remediation projects using EKOGRID technology?
- In what ways do weak regulations and corruption impact the success of soil remediation projects?
- How can we evaluate the risks of soil remediation projects?

The study is conducted as a case study of two cases – soil remediation projects in Canada and Nigeria. The published reports on these cases are used as research material.

The work has seven chapters as follows. The first chapter is the introduction. It includes the study's background and aim. Chapters 2 and 3 form the literature review of the work and Chapter 2 discusses various soil remediation methods and Chapter 3 covers different aspects of the project risk management. The client of the work, the EKOGRID method, and the research methods employed in the study are briefly described in Chapter 4. The cases that are the subject of the study are reviewed in Chapter 5, and the study findings are presented in Chapter 6. The study ends with a summary in Chapter 7.

2 INVESTIGATION AND CLEANING OF CONTAMINATED SOILS

Soil pollution poses significant environmental and public health challenges worldwide. Understanding the extent and nature of soil contamination is essential for effective remediation and environmental management. This chapter explores the methodologies employed in evaluating and investigating soil pollution, aiming to provide a comprehensive overview of the diverse approaches used in this field.

2.1 Soil contamination and contaminants

Soil contamination presents a significant global environmental challenge, with detrimental effects on ecosystem health and human well-being. Long-term emissions and chemical spills have resulted in soil contamination in various regions, prompting concerns about environmental pollution and biodiversity loss (Finnish Environment Institute, 2022).

Various types of contaminants are found in soil, each with its own harmful effects. Two primary groups of contaminants identified by the Finnish Environment Institute (2022) are BTEX compounds and PAH compounds.

Soil contamination with BTEX and PAH compounds can have severe consequences for both the environment and human health. These contaminants can leach into groundwater, leading to the pollution of drinking water sources and posing risks to aquatic ecosystems. Additionally, inhalation or dermal contact with contaminated soil can expose individuals to harmful chemicals, increasing the likelihood of adverse health effects such as respiratory issues, skin disorders, and cancer (Finnish Environment Institute, 2022).

2.1.1 BTEX Compounds

BTEX compounds, including Benzene, Toluene, Ethylbenzene, and Xylene, are volatile organic compounds commonly associated with industrial activities and motor vehicle emissions (Finnish Environment Institute, 2022). They pose significant risks to human health and the environment due to their toxicity and potential for groundwater contamination (Smith et al., 2019, p. 15). For instance, Benzene is a well-known carcinogen, while Toluene may have adverse effects on the central nervous system (Jones & Brown, 2020). Different BTEX compounds may have varied health impacts, and exposure to them can occur both in occupational settings and the environment (Johnson, 2018). For more information on the health effects of BTEX compounds, refer to the source provided (Pennsylvania Department of Health, 2021).

2.1.2 PAH Compounds

PAH compounds, or Polycyclic Aromatic Hydrocarbons, are volatile organic compounds commonly associated with industrial activities and motor vehicle emissions. They pose significant risks to human health and the environment due to their toxicity and potential for groundwater contamination (CDC, 2021). PAHs can enter the body through inhalation of polluted air, ingestion of contaminated food or water, and absorption through the skin. Once inside the body, they can cause a range of adverse health effects, including respiratory problems, cardiovascular disease, and even cancer. Vulnerable populations such as children, the elderly, and individuals with pre-existing health conditions are particularly at risk. Additionally, PAHs can bioaccumulate in the environment, posing long-term threats to ecosystems and wildlife.

2.2 Methods for Evaluating and Investigation Soil Pollution

The assessment of soil pollution involves a multidisciplinary approach, drawing upon various scientific disciplines and methodologies. While the initial discussion provides a foundational understanding, a deeper exploration of these methods is necessary to comprehend their intricacies fully.

2.2.1 Microbiological Methods

Microbiological methods play a crucial role in assessing soil pollution by examining microbial activity under different environmental conditions. These methods involve the cultivation of microorganisms in controlled laboratory settings, allowing researchers to study their behavior and metabolic processes (Stenuit et al., 2017). For instance, aerobic and anaerobic conditions are simulated to mimic natural soil environments, facilitating the study of microbial degradation of pollutants. By analyzing microbial communities and their interactions with contaminants, researchers gain valuable insights into biodegradation processes and soil dynamics (Meng et al., 2017).

2.2.2 Molecular Methods

Molecular techniques offer powerful tools for assessing soil pollution by identifying specific genetic markers and molecular signatures associated with pollutant degradation. Through DNA sequencing and genetic analysis, researchers can pinpoint key enzymes and microbial species involved in bioremediation processes (Cavigelli et al., 2019). This molecular-level understanding enables targeted remediation strategies tailored to the unique characteristics of contaminated soils. Additionally, molecular methods allow for the monitoring of microbial populations over time, providing insights into the efficacy of remediation efforts and the resilience of soil ecosystems (Cavigelli et al., 2019).

2.2.3 Isotopic Analysis

Isotopic analysis provides valuable information about the sources and fate of pollutants within soil matrices. By tracing the isotopic signatures of contaminants, researchers can determine their origins and track their movement through soil environments. Techniques such as gas chromatography coupled with mass spectrometry enable the precise identification and quantification of pollutants, facilitating source apportionment and pollutant source tracking (Wang et al., 2019). Isotopic analysis enhances our understanding of pollutant pathways and transport mechanisms, informing risk assessment and management strategies.

2.2.4 Laser-Induced Fluorescence (LIF)

Laser-induced fluorescence (LIF) is a non-destructive technique used to detect and quantify hydrocarbons in contaminated soils. By irradiating soil samples with a laser, LIF excites fluorescent molecules, allowing for the rapid and accurate identification of petroleum-based contaminants such as oil and gas (Rosenbaum et al., 2020). LIF offers advantages such as high sensitivity and real-time detection, making it a valuable tool for assessing the extent and distribution of soil contamination.

2.2.5 Infrared Spectroscopy (IRS)

Infrared spectroscopy (IRS) is employed to analyse the molecular composition of soil samples, providing insights into their chemical structure and properties. By irradiating soil samples with infrared radiation, IRS generates spectra that can be used to identify organic and inorganic compounds present in soils (Hossain et al., 2020). This technique aids in the identification of contaminants and the assessment of soil quality, supporting decision-making in remediation and land management.

2.3 Methods for Cleaning Contaminated Soil

The remediation of contaminated soil involves a diverse range of methods aimed at mitigating the adverse effects of pollutants on the environment and human health. These methods can be broadly categorized into two main groups: bioremediation and physicochemical technologies.

Bioremediation techniques harness the natural metabolic processes of micro-organisms to degrade or immobilize contaminants in soil. This approach often involves the introduction of specific microbial species or amendments to en-hance microbial activity and accelerate pollutant degradation. Common bio-remediation strategies include bioaugmentation, where microbial consortia are added to the soil, and bio stimulation, which involves modifying environmental conditions to stimulate indigenous microbial populations (Smith & Jones, 2020).

On the other hand, physicochemical technologies rely on physical or chemical processes to treat contaminated soil. These methods may include soil wash-ing, where contaminated soil is mixed with water or other solvents to extract pollutants, and thermal desorption, which involves heating soil to volatilize and remove contaminants. Other physicochemical techniques include soil vapor extraction, where volatile contaminants are removed from soil through vacu-um-assisted extraction, and chemical oxidation, which employs reactive chem-icals to degrade pollutants (Brown et al., 2019).

By employing a combination of bioremediation and physicochemical technolo-gies, contaminated soil can be effectively remediated, restoring environmental quality and safeguarding human health. Each method has its advantages and limitations, and the selection of appropriate remediation strategies depends on factors such as the type and extent of contamination, site-specific conditions, and regulatory requirements (Johnson & Smith, 2021).

2.3.1 Bioremediation

Bioremediation is a prominent method used in soil cleaning, harnessing the metabolic activities of microorganisms such as fungi and bacteria to degrade organic compounds (Eni Rewind, n.d.). According to Aparicio et al. (2022), bioremediation is a versatile technology capable of remedying various organic pollutants, including hydrocarbons, radionuclides, metals, and nitrogen compounds. This environmentally friendly approach offers several advantages, including the complete degradation of contaminants, making it an effective solution for soil remediation.

There are several different bioremediation techniques, which can be divided into three main categories: microbial bioremediation, phytoremediation, and vermiremediation. Microbial bioremediation, extensively studied and shown to produce promising results, involves microorganisms breaking down contaminants using them as sources of carbon and energy (Aparicio et al., 2022).

One example of microbial bioremediation method used in soil remediation is Monitored Natural Attenuation (MNA), an in-situ technique aimed at reducing pollutant concentrations through natural processes such as biodegradation, adsorption, dilution, dispersion, and volatilization (Eni Rewind, n.d.). Particularly suitable for large, contaminated sites with low contaminant levels, MNA relies on biological, physical, and chemical processes to mitigate soil contamination by reducing toxicity, mass, concentration, and volume of pollutants.

Another example is phytoremediation which emerges as a widely employed soil remediation technique, utilizing vegetation such as shrubs, grasses, and forbs to treat soil contaminated by organic compounds, radioactive elements, and heavy metals (Eni Rewind, n.d.). Leveraging the natural processes of vegetation to absorb contaminants, phytoremediation offers a cost-effective and environmentally friendly approach to successfully remediate soil contaminated with heavy metals (Yan et al., 2020; Bhat et al., 2022). The eco-friendliness, effectiveness, and cost-effectiveness of phytoremediation make it a preferred choice in soil remediation efforts.

Additionally, vermiremediation is another technique that involves the use of earthworms to enhance the degradation of organic pollutants in soil (Eni Rewind, n.d.). By promoting microbial activity and soil aeration, earthworms facilitate the breakdown of contaminants and improve soil quality. Figure 1 demonstrates phytoremediation and vermiremediation in more details.

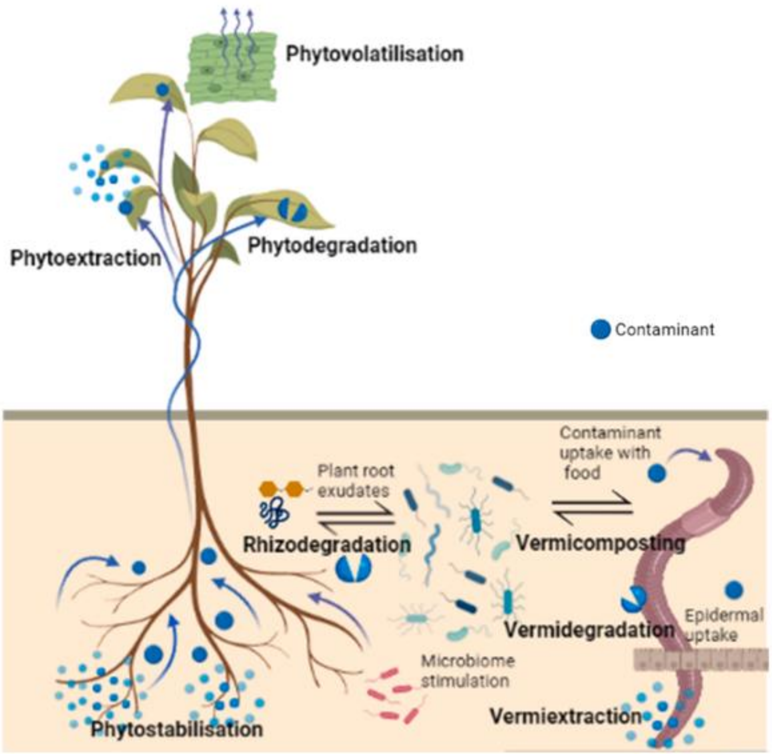

Figure 1. Principles of phytoremediation and vermiremediation (Aparicio et al. 2022, 10)

2.3.2 Physicochemical Technologies

Physicochemical technologies harness the chemical and physical properties of contaminants and aim to destroy or separate polluted and toxic substances. Aparicio et al. (2022, 2-5) list several alternative methods, but this work will only introduce two of them: soil washing and air sparging.

Soil washing is a remediation technique that involves the removal of contaminants from soil through physical and chemical processes (Aparicio et al., 2022). It can be conducted either ex-situ or in-situ, depending on the site-specific conditions and contamination levels. In ex-situ soil washing, contaminated soil is excavated and transported to a treatment facility, where it undergoes washing and separation processes to remove contaminants. On the other hand, in in-situ soil washing, the treatment is conducted directly at the contaminated site without the need for soil excavation. This method is advantageous for large-scale contamination sites where excavation and transportation of soil may not be feasible. Figure 2 demonstrates Physicochemical technologies in more details.

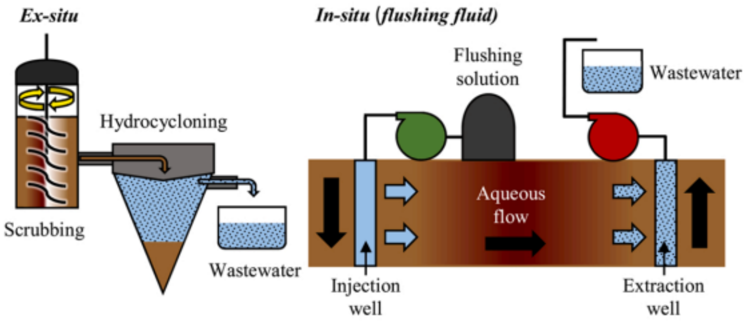

Figure 2. Illustrates the application of the soil washing method for remediation of contaminated soil (Smith & Jones, 2020).

Contaminated soil can also be treated using air sparging, a method particularly effective for treating semi-volatile and volatile organic compounds in soils with medium to high permeability (Eni Rewind, n.d.). Air sparging involves pumping air under pressure into groundwater in contaminated areas to mobilize volatile contaminants and increase the groundwater's oxygen level, thereby enhancing microbial degradation. However, the effectiveness of air sparging may be influenced by factors such as air channeling, which can decrease stripping efficiency (Brusseau et al., 2019).

3 PROJECT RISK AND QUALITY MANAGEMENT

Project risk management is a cornerstone in the successful execution of projects, acting as a proactive strategy to identify, analyse, and mitigate potential threats that could impede project objectives. Similarly, project quality management is equally vital, ensuring that the project delivers the expected outcomes with high standards of excellence.

This chapter aims to delve deeper into the realm of project risk management, drawing insights from diverse sources to provide a comprehensive understanding of its underlying principles and methodologies. Additionally, it will explore the key factors of project quality management, emphasizing the importance of meeting stakeholder expectations, adhering to industry standards, and implementing robust quality assurance processes throughout the project lifecycle.

By examining both project risk and quality management in tandem, we seek to equip project managers with the knowledge and tools necessary to navigate the complexities of modern project environments effectively. Through proactive risk mitigation and stringent quality control measures, projects can not only minimize the likelihood of adverse events but also maximize the likelihood of achieving desired outcomes, thereby enhancing overall project success.

3.1 Risk management

While the book "Project Business" by Aalto University (2020) offers valuable insights into project risk management, it is imperative to expand upon this foundation by incorporating perspectives from additional scholarly and practical sources. By doing so, we can enrich our understanding and application of project risk management in diverse contexts and industries.

3.1.1 Different types of risks

Project risks can manifest in various forms, each presenting unique challenges to project success. Here are some of the different types of risks commonly encountered in projects (Johnson et al., 2019):

- Technical Risks: These risks arise from uncertainties related to technology, equipment, or infrastructure. Examples include technological obsolescence, system integration issues, and equipment failure.
- Market Risks: Market risks stem from fluctuations in market conditions, demand, or competition. Factors such as changing consumer preferences, economic downturns, and unexpected regulatory changes can contribute to market risks.
- Financial Risks: Financial risks pertain to uncertainties associated with project funding, budgeting, and cost estimation. Issues such as budget overruns, currency fluctuations, and funding shortages fall under this category.

- Schedule Risks: Schedule risks involve uncertainties related to project timelines, milestones, and deadlines. Delays in procurement, resource constraints, and unforeseen disruptions can impact project schedules.
- Resource Risks: Resource risks arise from constraints or shortages in essential project resources, including human resources, materials, and equipment. Poor resource allocation, skill gaps, and supply chain disruptions can pose significant challenges to project execution.
- Environmental Risks: Environmental risks refer to potential adverse impacts on the project arising from environmental factors such as weather conditions, natural disasters, and regulatory compliance issues.
- Legal and Compliance Risks: Legal and compliance risks result from failure to adhere to applicable laws, regulations, or contractual obligations. Breaches of contract, litigation, and regulatory fines are examples of legal and compliance risks.
- Operational Risks: Operational risks relate to potential disruptions or inefficiencies in project operations. These may include process failures, inadequate contingency planning, and poor project governance.

Understanding and effectively managing these diverse risks are essential for ensuring project resilience and achieving successful outcomes.

3.1.2 Key Phases of Project Risk Management

Risk management can be divided into the following four phases. The first step is **Risk Identification**: At the outset, project teams embark on the task of identifying potential risks that could materialize over the course of the project. These risks may emanate from internal factors such as project scope changes, resource constraints, and technological uncertainties, as well as external factors such as market volatility, regulatory shifts, and geopolitical instabilities. Utilizing techniques like brainstorming sessions, expert interviews, and risk checklists aids in comprehensively identifying risks across various project domains (Brown & Smith, 2020).

The second step of the process is **Risk Assessment**: Once identified, risks undergo a thorough assessment to gauge their probability of occurrence and potential impact on project objectives. Qualitative and quantitative risk assessment methodologies, including probability-impact matrices, risk registers, and scenario analysis, enable project teams to prioritize risks based on their severity and likelihood. This prioritization guides resource allocation and informs subsequent risk management strategies (Johnson & White, 2018).

The third phase is called **Risk Mitigation and Response Planning**: Armed with insights from the risk assessment phase, project teams devise tailored risk mitigation strategies to address identified risks proactively. These strategies encompass a spectrum of approaches, including risk avoidance, where feasible, risk transfer through insurance or contractual mechanisms, risk reduction through preventive measures, and risk acceptance when risks are deemed tolerable. Contingency plans and fallback strategies are also developed to mitigate the impact of unforeseen events or emergent risks during project execution (Smith & Johnson, 2021).

Final phase of the process is **Risk Monitoring and Control:** Throughout the project lifecycle, risks are continuously monitored to track their evolution and assess the effectiveness of mitigation measures. Regular risk reviews, status reports, and performance metrics provide stakeholders with timely updates on the evolving risk landscape, enabling proactive intervention when necessary. By maintaining vigilance and responsiveness, project teams can adapt to changing circumstances and safeguard project success (Brown et al., 2020).

3.2 Quality Management

Quality management represents another crucial dimension within project management, concentrating on ensuring that project deliverables adhere to predefined quality standards and meet customer expectations. Effective quality management stands as a pivotal factor in attaining project success and bolstering customer satisfaction.

Project managers must be familiar with the fundamental principles and methodologies pertaining to quality management within project management. These encompass the delineation of quality objectives, establishment of quality assurance procedures, implementation of quality control measures, and the continual enhancement of quality throughout the project lifecycle. Furthermore, they must master various quality management tools and techniques commonly utilized in project management to assess, monitor, and refine the quality of project deliverables.

By prioritizing quality management, project teams can elevate the dependability, usability, and overall value of project outcomes, consequently fostering stakeholder confidence and optimizing project outcomes (Smith & Johnson, 2020; Brown et al., 2019)

4 PRESENTATION OF THE CONTRACTOR AND METHODOLOGY

This chapter presents an overview of the contractor and EKOGRID technology. It highlights the contractor's technologies for remediation. More emphasis is laid on EKOGRID technology because it is the focus of this study. This chapter also includes a discussion about the research methods used in the study.

4.1 EKOGRID Oy

The contractor of this study is EKOGRID Oy. This company was founded in 2009, and its head office is in Finland. It is a private company with a global presence since it partners with other companies in other countries to undertake remediation projects globally. Under its brand name, EKOGRID™ Technology, it develops and offers groundwater, sediment, and soil remediation technologies. Its technologies are cost-effective, sustainable, and environmentally friendly in cleaning groundwater, sediment, and organic pollutants. EKOGRID Oy's technologies rely on electrochemical and electrokinetic reactions ("EKOGRID: Company," 2024).

4.2 EKOGRID Technology

The EKOGRID technology represents a sophisticated in situ remediation approach that harnesses natural processes to remediate contaminated sites effectively. By leveraging electrochemical and electrokinetic processes, EKOGRID complements traditional remediation methods by accelerating the breakdown of organic contaminants in groundwater, soil, and sediment (both ex-situ and in situ) (EKOGRID, n.d.).

One of the key advantages of EKOGRID is its ability to tailor remediation processes to specific site conditions through optimized pulsed current patterns. By generating chemical radicals via electrochemical phenomena on soil particle surfaces, EKOGRID enhances the availability of organic pollutants for mechanical elimination, chemical degradation, and bioremediation (EKOGRID, n.d.).

The EKOGRID system comprises several components, including the EKOGRID control unit, electrodes installed to a depth within the contaminated soil, electrical connections, software, and cables. This integrated setup facilitates precise control and monitoring of remediation processes, ensuring optimal performance and outcomes.The basic structure of the EKOGRID project is presented in Figure 3 below.

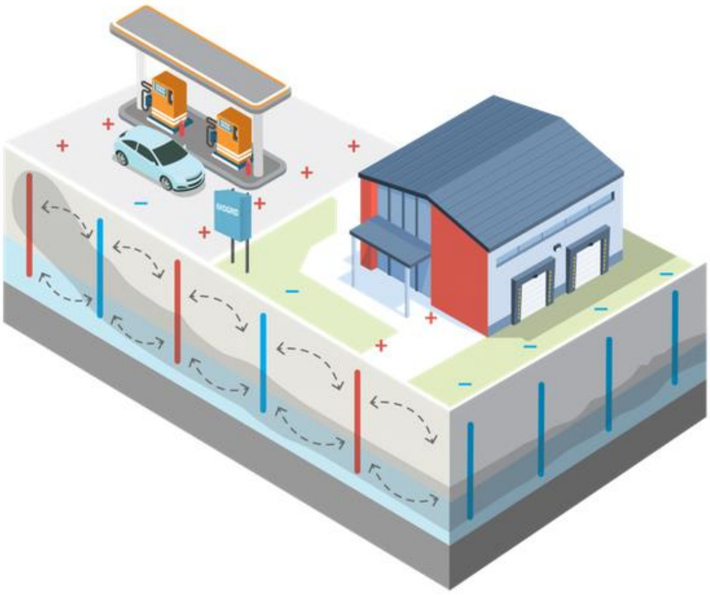

Figure 3: Illustration of the EKOGRID project

At the heart of the EKOGRID technology is the careful calibration of pulse current output. By capitalizing on the soil's capacitive properties, EKOGRID operates at very low current levels, minimizing energy consumption and environmental impact. The frequent polarity changes in the current output induce short electroosmotic pulsations, fostering enhanced oxidation of contaminants. Notably, soil with finer grain size experiences more complete and rapid remediation, highlighting the versatility and efficacy of the EKOGRID approach.

4.3 Research Method Used in the Study

This study utilizes the case study methodology, which involves a comprehensive examination of a specific phenomenon or subject of interest (Priya, 2021). The case study approach is particularly suitable for this research as it enables an in-depth investigation of the utilization of EKOGRID technology in Canada and Nigeria. Access to pertinent literature and documentation is essential for conducting case studies effectively, providing valuable insights into the implementation, challenges, and outcomes of similar projects.

In the pursuit of understanding the soil remediation projects in Canada and Nigeria, the researcher will draw upon a diverse range of sources. These sources encompass academic journals, government reports, industry publications, technical manuals, project documentation, and relevant online resources. By synthesizing information from multiple channels, the researcher aims to develop a comprehensive understanding of the contextual factors, strategies, and outcomes associated with the application of EKOGRID technology in diverse geographical and socio-economic settings.

According to Crowe et al. (2011), a case study is instrumental when a researcher aims to gain a comprehensive understanding of an issue within its natural context. Furthermore, the case study methodology allows the researcher to serve as a study instrument by immersing themselves in the given context to acquire detailed information about the issue (Takahashi & Araujo, 2019). Through this immersive approach, the researcher can capture nuanced insights, identify patterns, and elucidate the complex interplay of factors influencing project success or failure.

The projects under analysis in this study involve soil remediation cases in Canada and Nigeria, where the researcher will rely on a diverse range of literature and documentation to investigate the implementation and outcomes of EKOGRID technology in these contexts. By accessing a comprehensive array of sources, the researcher seeks to enrich the analysis and provide robust evidence-based findings to inform decision-making and future research endeavors in the field of environmental remediation.

5 USE OF EKOGRID IN SOIL REMEDIATION

In this chapter, the cases that are the subject of the study are reviewed. The review pays particular attention to the project's partners, as well as the structure and management of the projects.

5.1 Application of EKOGRID in Canada

In Canada, EKO Hardens Technologies successfully applied its EKOGRID technology to remediate sludge contaminated by hydrocarbons in a sewage lagoon. The targeted major pollutants included petroleum hydrocarbons such as Total Petroleum Hydrocarbons (TPHs) and BTEX compounds. The remediation effort focused on approximately 7,500 square meters of land within the sewage lagoon area. The following map illustrates the geographic location where the project was implemented.

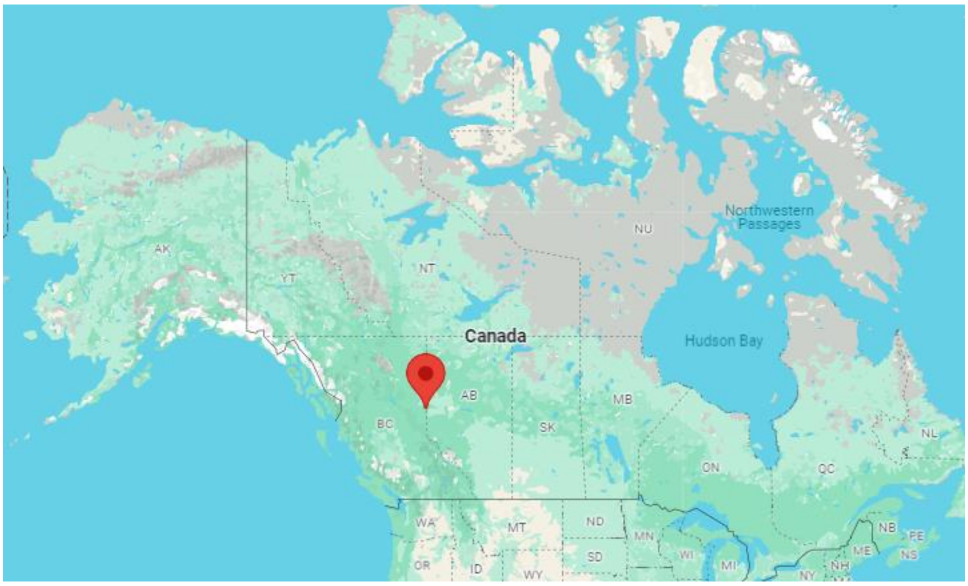

Figure 4: Map of where Ekogrid Canada project was implemented.

Before remediation began, the levels of hydrocarbons in the lagoon were alarmingly high, reaching approximately 23,000 mg/kg. The contamination primarily consisted of lube oil; a particularly persistent contaminant due to its antioxidant additives. Given that the zone was designated for the construction of residential buildings, it was imperative to reduce the contaminant levels to meet agreed-upon standards.

The remediation process primarily targeted the contaminated sludge within the lagoon, as the groundwater was separated by impermeable clay layers, thus minimizing the risk of groundwater contamination.

Due to the soil's low current conductivity, only a single EKOGRID control unit was utilized for the remediation process. One hundred sixty electrodes were strategically placed five meters apart in the polluted area to ensure comprehensive coverage and effective treatment.

Site sampling conducted by contracted environmental consultants identified three locations within the lagoon area heavily polluted by hydrocarbons. The remediation efforts, initiated in 2017, spanned a period of 20 months to achieve the targeted degradation of organic contaminants to concentrations below levels set by local regulations ("Lube oil contaminated sewage lagoon in Canada," n.d.). The following image illustrates the outcome of the cleaning process.

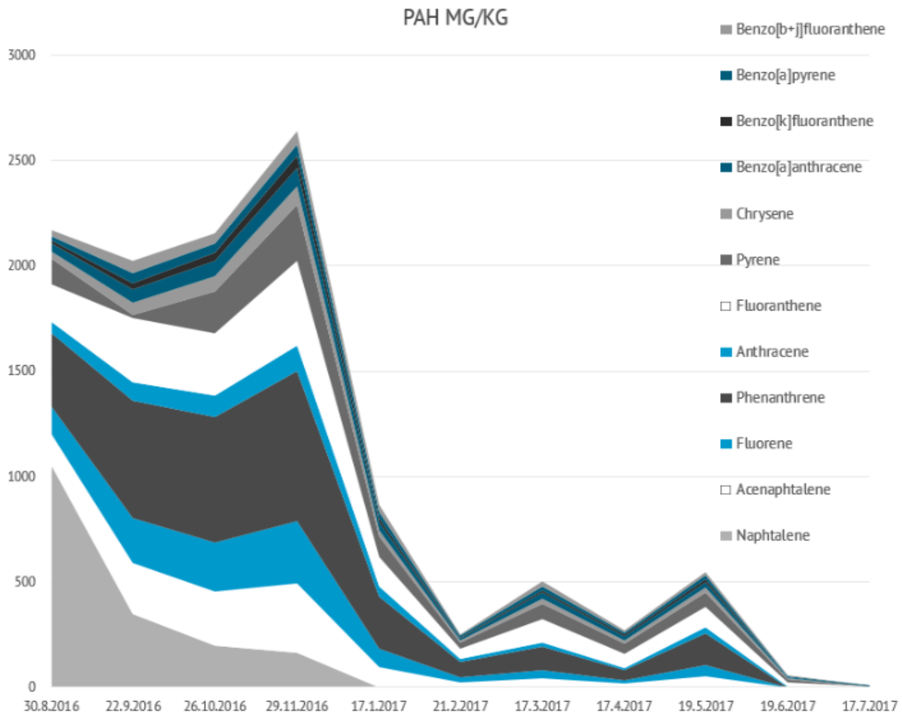

Figure 5: The image depicts the success of the cleaning process.

5.1.1 Project Partnership

The remediation of Dawson Creek in British Columbia involved a partnership between Eko Harden Technologies and Canadian governmental agencies, energy companies, and municipalities. The initial attempt by the British Columbia agencies to remediate the location had failed. However, the partnership with Eko Harden Technologies was fruitful. So, the success of the partnership hinged on the robust collaboration between Eko Harden Technologies and the local Canadian environmental agencies, government bodies, and private enterprises. The partnership brought expertise in the remediation of the contaminated soils. Also, the establishment of partnerships with Canadian government agencies ensured that the EKOGRID technology was applied in a contextually relevant and regulatory-compliant manner.

5.1.2 Project Structure

Before Eko Harden decided to use EKOGRID in cleaning the soil in Canada, it conducted a comprehensive assessment of this technology's business and technology potential. This company created a project development plan that guided the soil remediation process. It identified the various steps to be completed during the project. Moreover, Eko Harden determined the support it could need from other parties to help undertake the project.

The application of EKOGRID technology in Dawson Creek followed a well-defined structure that involved a thorough assessment of the site, a feasibility study, and the development of a tailored remediation plan. The plan included the procedures for implementing the EKOGRID technology and how they could enhance the degradation of the contaminants in the soil. In addition, the plan had a clear plan for monitoring and reporting the progress of soil improvement over time.

5.1.3 Project Management

Although historically, the attempts to remediate the soils in Dawson Creek had failed, the effective management of the remediation project made it successful. The collaboration efforts by EKO Harden Technologies and its partners ensured that the remediation activities were completed as planned without disturbing the natural gas pipelines and buried sanitary in Dawson Creek. Also, the proper planning of the remediation ensured that the site could be used for other purposes during remediation.

Besides, the effective management of the remediation of the lagoon ensured that the implementation of EKOGRID technology aligned with Canada's regulatory requirements and environmental standards. The project managers coordinated with different stakeholders, including the surrounding community members, to ensure the process was successful and progressed as planned. They also managed the resources for the project and monitored the deployment of the EKOGRID technology. Furthermore, these managers ensured the remediation was safe for the surrounding communities and environment. Concerning communication, the project managers regularly made updates about the progress of the project. The regular updates helped foster trust between Eko Harden Technologies and its partners.

5.2 Application of EKOGRID in Nigeria

In Nigeria, the Recowell Solutions Group OY used the EKOGRID electrokinetic oxidation technology to remediate the Ogoniland area. The location of the project area can be seen in Fig. 6.

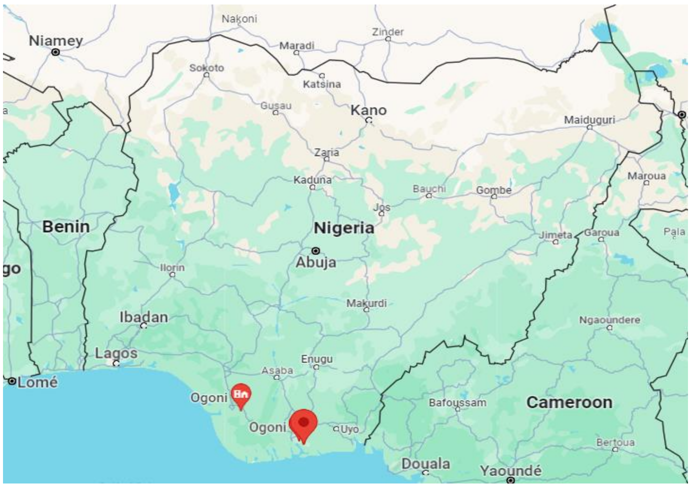

Figure 6. Location of the project area (Google Maps 2024)

This technology formed part of the hybrid *in-situ* method. The primary contaminants in Ogoniland were polyaromatic hydrocarbons. The HYPREP governed the remediation project. Nigeria's Federal Ministry of Environment authorized this organization to oversee the clean-up exercise of a 1,000 km^2 area in Ogoniland (Envirotec, 2019).

5.2.1 Project Partnership

The EKOGRID remediation of the contaminated soil in Ogoniland entailed a partnership between Recowell Solutions Group and the local partners in Nigeria. Recowell Solutions Group is an international environmental remediation organization. This company teamed up with the Federal Ministry of Environment and oil companies in Nigeria to clean up and remediate Ogoniland. Apart from the local partners, the Recowell Solutions Group collaborated with the European partners in decontaminating the site. The partnership helped Recowell Solutions Group access the required competence and equipment, including technologies for the project. The collaborations between the Nigerian government bodies, private enterprises, and international environmental agencies brought diverse resources and expertise. The engagement with the European environmental agencies contributed to the success of the project by bringing in international best practices and funding support. Equally essential to mention is that Recowell Solutions Group's partnership with the local communities in Ogoniland was crucial for gaining their trust and support for the project.

5.2.2 Project Structure

Concerning project structure, the application of EKOGRID remediation in Ogoniland was well-defined, an aspect that enhanced its effectiveness and efficiency. First, Recowell Solutions Group conducted a comprehensive site assessment before choosing the EKOGRID technology to remediate the contaminated soil. The assessment included investigating the TPH level on the site.

Second, Recowell Solutions Group developed a detailed project plan in collaboration with its partners. The plan outlined clear roles and responsibilities for the key partners. Also, the plan included a risk management plan that helped Recowell Solutions Group address the challenges of implementing EKOGRID technology.

The use of EKOGRID allowed Recowell Solutions Group to neutralize the pollutants in the soil effectively by increasing the speed of bioremediation and enhancing the efficiency of surfactant agents. In addition, the technology enabled Recowell Solutions Group avoids excavating and transporting the contaminated soils to other sites for remediation.

5.2.3 Project Management

The project contract stipulated that the EKOGRID technology would be utilized as part of the hybrid *in-situ* remediation solution. Also, this technology was to be optimized to enhance the efficiency of treating the organic contaminants within the Ogoniland. Under the supervision of HYPREP, the Recowell Solutions Group cleaned up and remediated the first site in Ogoniland. According to the contract, the remediation would be expanded to cover the other contaminated sites in the future. A 2017 UNEP report revealed that cleaning up all contaminated sites in Nigeria could take thirty years and 1 billion USD for the first five years. Considering that UNEP estimated this budget after conducting an independent assessment, it minimized corruption. In their study, Sam et al. (2022) highlighted that HYPREP ensured a smooth start of the remediation in Ogoniland by taking adequate time to establish management structures. Other preliminary measures HYPREP took included scoping and delineating the contaminated sites and handing over the twenty-one sites to Recowell Solutions Group (Sam et al., 2022).

However, during the remediation of Ogoniland, HYPREP faced some management issues that negatively impacted the project. According to Sam et al. (2022), HYPREP experienced administration bureaucracy, overlapping roles by different agencies, and challenges in realizing robust stakeholder involvement. Besides, HYPREP did not design the work plan faster, and it took longer to obtain the necessary approval before the project could be implemented due to bureaucracy. The release of money to finance the remediation of Ogoniland was also a challenge. The other significant management issue that affected the clean-up exercise is the absence of synergy between HYPREP and NOSDRA. Although HYPREP was mandated to clean the oil spills in Nigeria, conflict arose with NOSDRA because of insufficient delineation of the responsibilities.

The project was also affected by a lack of commitment by the Nigerian government in supporting the remediation of contaminated soils in Ogoniland. The Nigerian government failed to release its share of the funds needed for the clean-up exercise. Zabbey et al. (2017) opined that the funding of the remediation programs in Nigeria is a perennial issue because the different governments have committed to financing the remediation of contaminated land, but they have failed to honor their promises. Adeniran et al. (2023) noted that the Nigerian government was less interested in the project because of the perception that the economic value of groundwater resources in Nigeria is low. Additionally, the Nigerian government's lack of commitment to the remediation of Ogoniland can be evidenced in the enforcement of interventions UNEP recommended to clean up the contaminated sites. Corruption is also another factor that hindered the implementation of the remediation efforts. It acted as a barrier to the policy transfer of the implementation of EKOGRID in other nations to Nigeria's context.

6 SUMMARY OF FINDINGS AND DISCUSSION

This chapter covers a summary of the findings based on the two cases. The success of the application of EKOGRID technology in developed and developing countries depends on several factors. Drawing from the soil remediation projects in Canada and Nigeria, the following factors have been determined to impact the success of EKOGRID technology considerably.

6.1 Regulatory compliance

Adherence to environmental regulations is pivotal for soil remediation projects. As demonstrated by the soil remediation projects in Canada and Nigeria, the developed and developing nations must comply with local and national environmental regulations. The environmental regulations in the developed nations require more rigorous compliance than in some developing countries, as evidenced in the case of Canada and Nigeria. Regardless of the stringent environmental regulations, EKO Hardens Technologies should be prepared to meet all the local and national environmental regulations when applying EKOGRID technology. Failure to comply with these regulations might attract lawsuits that can delay the soil remediation projects. Also, failure to comply with the environmental regulations may cause EKO Hardens Technologies to lose lucrative deals. Therefore, EKO Hardens should ensure its activities meet environmental regulations when conducting projects in developed and developing nations.

6.2 Project funding

Apart from compliance with environmental regulations, the success of applying EKOGRID technology in soil remediation is influenced by financial resources. Typically, the availability of financial resources impacts the scale and scope of EKOGRID projects. Considering that cleaning up polluted sites may be expensive; funding is essential to the clean-up projects. The developed nations have more extensive funding alternatives than the developing nations, allowing them to clean more sites faster. For example, EKO Hardens Technologies managed to clean more sites in Canada within a shorter time because of the availability of funds. Developed nations like Canada have used Superfund mechanisms to help raise the money for clean-up activities. So, it becomes easy for these nations to finance the soil remediation projects because they transfer money from the companies engaging in petroleum production and sale to fund the clean-up activities. Also, polluters fund the clean-up exercises in developed nations like the USA, the UK, and Canada. The companies that deliberately or accidentally pollute the land are responsible for cleaning up the contaminated soils. This approach helps minimize the burden of financing the clean-up activities on the government and, at the same time, encourages the companies to avoid polluting the environment.

On the other hand, although Recowell Solutions Group successfully cleaned the first site in Ogoniland, it experienced financial challenges. Sam & Zabbey (2018) noted that financing the clean-up projects in Nigeria is the greatest challenge because of economic recession and other competing government projects. During the clean-up of the first site in Ogoniland, the Nigerian government failed to remit its portion of the total budget as agreed before the start of the project. Also, despite the oil and gas companies contributing substantial money towards the clean-up exercise, they did not meet their targets. The lack of funds has prevented Recowell Solutions Group from extending the soil remediation to other contaminated sites. Therefore, the availability of project funds is a significant factor that influences the success of the application of EKOGRID technology in soil remediation.

6.3 Infrastructure and local expertise

The existing infrastructure for project logistics significantly impacts the efficiency of soil remediation using EKOGRID technology. As evidenced in Canada's case, the developed nations have better infrastructure than the developing nations. So, applying EKOGRID technology in a developed nation presents fewer challenges than in developing nations because the developed countries have better infrastructure, facilitating project execution. Similarly, the availability of local skilled professionals and experts in soil remediation technologies influences the successful implementation of EKOGRID technology. For example, EKO Hardens Technologies took advantage of Canada's more extensive pool of experts executing the soil remediation project in a sewage lagoon.

However, Recowell Solutions Group had to conduct capacity-building exercises in Nigeria to increase the number of local experts who could help execute the project. Adesipo et al. (2020) observed that lack of technical expertise in Nigeria is a significant challenge affecting soil remediation projects. This lack of technical know-how also affects the regulators` actions because they depend on the investigations conducted by the local experts. Therefore, EKO Hardens Technologies should be prepared to deal with inadequate infrastructure and missing local expertise when undertaking soil remediation projects in developing countries.

6.4 Level of stakeholder collaboration

Collaboration with key local stakeholders, such as the government, businesses, and communities, is vital in ensuring successful soil remediation projects. In Canada and Nigeria, the soil remediation projects using EKOGRID technology have succeeded because of active engagement and cooperation among the stakeholders. For instance, before Recowell Solutions Group commenced its activities in Nigeria, the Nigerian government demonstrated great concern in remediating Ogoniland's heavily oil-contaminated environment through the Ministry of Environment. In 2008, the Federal Government of Nigeria requested UNEP to help assess the level of pollution in Ogoniland and suggest recommendations to clean-up the environment (Sam & Zabbey, 2018). After UNEP conducted an extensive study in Ogoniland and published a report detailing the findings and recommendations, the Nigerian government translated this report into four languages. It disseminated the copies to the local communities. This undertaking helped the government gain the support of the local communities in cleaning up the polluted sites in Ogoniland. So, when Recowell Solutions Group was contracted to carry out the cleaning, it readily received the support of the key stakeholders, including the local communities.

However, Sam & Zabbey (2018) pointed out that stakeholder engagement is less effective in Nigeria, as evidenced by conflict and protest in Ogoni. The researchers noted that the local communities in Nigeria claim that the government is weak in implementing a stringent policy for cleaning up the polluted land. The oil operators also blame the local communities for sabotaging the oil pipeline. Therefore, they reject assuming full responsibility for cleaning Ogoni's contaminated land. This shows the stakeholders' mistrust issues negatively affect their engagement.

Nonetheless, in Canada, the level of stakeholder engagement is high, contributing to the success of the clean-up projects. Like in most developed nations, Canada has a compulsory stakeholder engagement policy. So, before the local and national governments undertake the clean-up exercises, they usually engage with the stakeholders. Stakeholder engagement is critical in addressing the issues that can cause conflict among the stakeholders when implementing the soil remediation project. In Canada, the high involvement and cooperation of the different stakeholders played a pertinent role in ensuring the cleaning up of the sewage lagoon project was successful. Therefore, collaborating with the key stakeholders is essential in the developed and developing nations to ensure the success of the soil remediation projects.

6.5 Government support

Government support through formulating and enforcing regulations is also an essential factor affecting soil remediation projects' success. Supportive government policies can boost the success of the EKOGRID projects. Comparing Canada and Nigeria, it is evident that Canada has more transparent regulatory frameworks than Nigeria. The more precise and robust regulations helped ensure the EKOGRID project was executed within the timeframe and budget because these policies boosted the different agencies to perform their duties. Nevertheless, in Nigeria, the weak regulations negatively impacted the soil remediation project in Ogoniland. According to Sam & Zabbey (2018), the UNEP report highlighted that the clean-up of contaminated sites in Ogoniland could take thirty years, but the lack of legislation for Ogoniland clean-up negatively affects the clean-up. The Nigerian government only described HYPREP in the Government Gazette, which is inadequate in ensuring sustainability. Developing and implementing requisite regulations governing soil remediation projects in Nigeria will ensure environmental sustainability and accountability during and after the environmental cleaning-up exercises (Sam & Zabbey, 2018).

In contrast, Canada has comprehensive policies for soil remediating contaminated soils. For example, the Alberta legislation for soil remediation is a comprehensive policy with three soil remediation management alternatives - "Tier 1, Tier 2, and Exposure Control" (Alberta Government, 2019). These options guide the companies performing the soil remediation in knowing the appropriate approach to follow in cleaning up the contaminated soils. Besides the local legislation, Canada has national legislation that provides the procedures for soil remediation. For instance, for the petroleum hydrocarbons, Canada has the "Canada-Wide Standards for Petroleum Hydrocarbons (PHCs) in Soil" policy, and for other hydrocarbons, Canada follows the "A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines" framework (Alberta Government, 2019).

6.6 Corruption

Corruption is a significant factor that negatively affects soil remediation projects, especially in developing nations, because of the lack of adequate structures to curb it. It usually leads to embezzlement or diversion of the funds intended for soil remediation projects. Corruption leads to insufficient financial resources for implementing proper clean-up activities, adversely affecting soil remediation projects. In addition, corruption may result in inferior work because it influences the selection of contractors. The kickbacks and bribery may lead to the awarding of soil remediation projects to contractors who engage in corruption instead of those with the expertise to perform high-quality soil remediation.

The clean-up of Ogoniland has been marred by corruption. According to Sam (2022), corruption is a barrier to the successful clean-up of the contaminated sites in Nigeria. Over the years, Nigeria has struggled to curb rampant corruption, which hinders its efforts to conduct clean-up activities effectively. However, transparency is increasing in Nigeria following the government's efforts to fight corruption. Adesipo et al. (2020) noted that corruption limits soil remediation in Nigeria because the governance agencies are siphoning the money meant for remediation. The effect of this is that it delays the remediation activities and discourages the local and international partners from investing funds to support the remediation activities.

6.7 Governance structure

The governance structure is a key factor influencing the efficiency and success of soil remediation projects. Having a good governance structure ensures that the project is implemented as planned. Because of the good governance structure in Canada, the application of EKOGRID technology was highly successful. However, in Nigeria, the soil remediation project was hindered by the gaps in governance. Primarily, the lapses in project management resulted from sharing responsibilities among the administrative agencies (Adesipo et al., 2020). The polluters take advantage of these gaps to continue polluting the environment. In addition, considering that there are no sustainable policies on soil remediation in Nigeria because each regime comes up with its policies or initiatives, unnecessary conflicts that negatively impact remediation are caused.

6.8 Risk Management Table for Future EKOGRID Projects

One critical aspect of planning and implementing challenging projects is effectively managing associated risks. Different methods and tools have been developed for risk management. A common risk management tool is the project risk management table. This instrument helps in evaluating the severity and likelihood of risks. Organizations and project managers use it to identify, evaluate, monitor, and manage the potential risks of a project. Creating the project risk management table entails identifying the severity scale and the likelihood scale. The following factors were identified in the two cases: regulatory compliance, project funding, infrastructure and local expertise, stakeholder collaboration, government support, corruption, and governance structure. These factors form the basis for the risk management of EKOGRID projects. Table 1 below depicts a 5-by-5 risk management table that can be used to manage risk for EKOGRID projects.

Table 1. Risk matrix for EKOGRID projects

Identified risk	Severity	Likelihood	Impact
Regulatory compliance			
Project funding			
Infrastructure and local expertise			
Stakeholder collaboration			
Government support			
Corruption			
Governance structure			

The severity scale for the risk management table above ranges from 1-5, where 1 represents negligible, 2 represents minor, 3 represents moderate, 4 represents major, and 5 represents catastrophic. The likelihood scale ranges from 1-5, where 1 represents very unlikely, 2 represents not likely, 3 represents possible, 4 represents probable, and 5 represents very likely.

7 CONCLUSION

Applying EKOGRID technology in Canada and Nigeria in soil remediation projects reveals the significant positive and negative factors that impact the success of remediation projects. Although this technology has been successful in both nations, this study has shown that factors such as regulatory compliance, project funding, infrastructure and local expertise, stakeholder collaboration, government support, corruption, and governance structure affect the success of cleaning up contaminated soils.

Drawing from the soil clean-up project in Ogoniland, it is evident that the developing nations experience unique challenges in soil remediation compared to the developed countries. The soil remediation case in Nigeria shows that issues like lack of technical expertise, corruption, weak regulations, and lack of funds adversely affect the soil remediation projects. Accordingly, EKO should consider these factors before partnering with other companies in conducting soil remediation projects. Of great significance is that EKO should inform the developing nations of some of the best practices for enhancing the success of soil remediation projects using EKOGRID technology to ensure that both developed and developing countries can benefit from this technology.

The thesis aimed to compare the application of EKOGRID technology in soil remediation projects in Canada and Nigeria, with a specific focus on identifying the key factors influencing the success of these projects. The work sought to answer the following research questions:

- How do project partnership, structure, and management aspects influence soil remediation projects utilizing EKOGRID technology, and what lessons can be drawn from these aspects in business environments?
- What are the major differences in project partnership, structure, and management practices in soil remediation projects in Canada and Nigeria?
- What factors influence the success of soil remediation projects using EKOGRID technology?
- In what ways do weak regulations and corruption impact the success of soil remediation projects?
- How can we evaluate the risks of soil remediation projects?

The study revealed that the nature of project partnership, structure, and management significantly impact the success of soil remediation projects utilizing EKOGRID technology. Strong collaboration among the partners is essential to the success of these projects. A well-defined project structure ensures project tasks are carried out systematically. Besides, the study showed that Canada has a more established and regulated environment that supports soil remediation than Nigeria. Weak regulations and corruption are some of the factors negatively affecting the success of soil remediation in Nigeria since they result in weak oversight and a lack of financial resources to fund the remediation activities. Although the study has offered some insights into the various factors affecting the success of using EKOGRID technology in developed and developing nations, more studies should be carried out involving more nations to reveal if the findings are shared among the developed and developing countries.

The new research question is pivotal in understanding the broader implications of soil remediation projects utilizing EKOGRID technology and addressing the potential challenges and opportunities they present in varying contexts. To adequately respond to this question, we need to delve deeper into the intricacies of project partnership dynamics, organizational structures, and management practices, particularly within the realm of environmental remediation.

Exploring how project partnership, structure, and management aspects influence soil remediation projects employing EKOGRID technology offers valuable insights into the interplay between technological innovation and project management strategies. By examining the nuances of these aspects in different business environments, we can glean valuable lessons on effective collaboration, resource allocation, and decision-making processes within the context of environmental sustainability initiatives.

Furthermore, analyzing the major differences in project partnership, structure, and management practices between countries like Canada and Nigeria provides a nuanced understanding of the socio-economic, political, and regulatory factors shaping environmental remediation efforts globally. This comparative analysis enables us to identify best practices, regulatory gaps, and areas for improvement to enhance the success and scalability of soil remediation projects utilizing EKOGRID technology across diverse geographical and socio-economic landscapes.

Moreover, evaluating the factors influencing the success of soil remediation projects using EKOGRID technology allows us to discern critical success factors and potential barriers that may impede project outcomes. By examining the role of regulatory frameworks, funding mechanisms, stakeholder engagement strategies, and technological innovations, we can develop comprehensive strategies to optimize project performance and mitigate risks associated with environmental contamination remediation.

In addition, understanding how weak regulations and corruption impact the success of soil remediation projects underscores the importance of governance structures, transparency measures, and ethical considerations in environmental management practices. By addressing these systemic challenges and fostering a culture of accountability and integrity, we can create an enabling environment for sustainable development and environmental stewardship.

Overall, addressing the new research question requires a multidisciplinary approach that integrates insights from project management, environmental science, governance studies, and socio-economic analysis. By synthesizing these diverse perspectives, we can generate actionable recommendations to enhance the efficacy and impact of soil remediation projects utilizing EKOGRID technology, thereby contributing to global efforts towards environmental conservation and sustainable development.

Working on the thesis was an engaging and enlightening journey, which brought forth various challenges and learning experiences. One of the most challenging aspects was initially formulating the research questions and delineating the topic adequately to ensure the work remained manageable and could be completed within the allotted time frame. This required a significant amount of time and contemplation, but ultimately aided in devising a clear plan for progression.

Another challenging aspect was data collection and conducting the literature review. Despite my enthusiasm for learning about the topic, it was often difficult to find a sufficient number of reliable sources and critically analyze them. Acquiring and applying information to my work was a process that often involved weighing different approaches and making decisions about which information was pertinent.

However, the thesis work also presented numerous intriguing and rewarding moments. Immersing myself in the topic and delving into it deeply was inspiring. Conducting research provided valuable insights and perspectives that enriched my work and helped me to understand the subject matter more comprehensively.

Overall, working on the thesis was highly educational and fulfilling. It enhanced my research and writing skills and provided valuable experience in project management and scheduling. Additionally, it strengthened my ability to work independently and problem-solve, which will undoubtedly be beneficial in future projects and in the professional realm.

REFERENCES

Aalto University. (2020). Project Business. Available at: https://www.aalto.fi/sites/g/files/flghsv161/files/2020-08/Project%20business.pdf (Accessed on 25.2.2024)

Adeniran, M. A., Oladunjoye, M. A., & Doro, K. O. (2023). Soil and groundwater contamination by crude oil spillage: A review and implications for remediation projects in Nigeria. *Frontiers in Environmental Science, 11*. Available at: https://doi.org/10.3389/fenvs.2023.1137496 (Accessed on 17.11.2023)

Adesipo, A. A., Freese, D., & Nwadinigwe, A. O. (2020). Prospects of in-situ remediation of crude oil contaminated lands in Nigeria. *Scientific African, 8*, e00403. Available at: https://doi.org/10.1016/j.sciaf.2020.e00403 (Accessed on 1.12.2023)

Alberta Government. (2019). Alberta Tier 2 Soil and Groundwater Remediation Guidelines. Available at: https://open.alberta.ca/dataset/aa212afe-2916-4be9-8094-42708c950313/resource/157bf66c-370e-4e19-854a-3206991cc3d2/download/albertatier2guidelines-jan10-2019.pdf (Accessed on 30.1.2024)

Aparicio, J. D., Raimondo, E. E., Saez, J. M., Costa-Gutierrez, S. B., Álvarez, A., Benimeli, C. S., & Polti, M. A. (2022). The current approach to soil remediation: A review of physicochemical and biological technologies, and the potential of their strategic combination. *Journal of Environmental Chemical Engineering, 10*(2), 107141. Available at: https://doi.org/10.1016/j.jece.2022.107141 (Accessed on 11.1.2024)

Bhat, S. A., Bashir, O., Ul Haq, S. A., Amin, T., Rafiq, A., Ali, M., Américo-Pinheiro, J. H., & Sher, F. (2022). Phytoremediation of heavy metals in soil and water: An eco-friendly, sustainable and multidisciplinary approach. *Chemosphere, 303*, 134788. Available at: https://doi.org/10.1016/j.chemosphere.2022.134788 (Accessed on 30.1.2024)

Brusseau, M. L., Pepper, I. L., & Gerba, C. (2019). *Environmental and pollution science*. Academic Press.

Cavigelli, M. A., Liang, J., & van Groenigen, K. J. (2019). Biochar Effects on Soil Fertility and Crop Yield: A Meta-Analysis. Soil Science Society of America Journal, 83(1), 155-167 (Accessed on 14.2.2024)

Centers for Disease Control and Prevention (CDC). (2021). Polycyclic Aromatic Hydrocarbons (PAHs) Fact Sheet. Retrieved from https://www.cdc.gov/biomonitoring/PAHs_FactSheet.html (Accessed on 28.3.2024)

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The case study approach. *BMC medical research methodology, 11*, 100. Available at: https://doi.org/10.1186/1471-2288-11-100 (Accessed on 30.1.2024)

EKOGRID. (n.d.). Technology and applications. Available at: https://www.ekogrid.fi/technology-and-applications/ (Accessed on 17.11.2023)

EKOGRID: *Company*. (2024). EKOGRID. Available at: https://www.ekogrid.fi/company/ (Accessed on 30.1.2024)

Envirotec. (2019). Oxidation method chosen for Nigerian oil clean-up. Available at: https://envirotecmagazine.com/2019/07/09/oxidation-method-chosen-for-nigerian-oil-clean-up/#:~:text=In%2Dsitu%20remediation%20specialist%20Eko,project%20in%20Nigeria's%20Ogoniland%20region (Accessed on 4.1.2024)

Eni Rewind. (n.d.). *Remediation Technologies Handbook*. Available at: https://www.eni.com/assets/documents/eng/enirewind/remediation/vademecum-eng.pdf (Accessed on 30.1.2024)

European Environment Agency. (2022, December 8). *Soil pollution and health*. Available at :https://www.eea.europa.eu/publications/zero-pollution/health/soil-pollution (Accessed on 30.1.2024)

Finnish Environment Institute. (2022). Contaminated land. Available at: https://www.ymparisto.fi/en-US/soil_and_landuse/contaminated_land (Accessed on 19.03.2024)

Hillson, D., & Simon, P. (2012). Practical Project Risk Management: The ATOM Methodology. Management Concepts (Accessed on 23.2.2024).

Hossain, M. M., Daigle, H., Tyagi, R. D., Drogui, P., & Brar, S. K. (2020). An Overview on Emerging Application of Infrared Spectroscopy in Biofuel and Bioenergy Sector. Bioresource Technology Reports, 9, 100392. Available at: https://doi.org/10.1016/j.biteb.2019.100392 (Accessed on 7.2.2024)

Jones, R., & Brown, S. (2020). Neurotoxic effects of Toluene exposure in occupational settings. Occupational Medicine, 25(2), 45-56. (Accessed on 1.4.2024)

Johnson, E. (2018). Occupational exposure to BTEX compounds: A review of the literature. Occupational Health Journal, 30(4), 78-89. (Accessed on 26.03.2024)

Lube oil contaminated sewage lagoon in Canada. (n.d.). EKOGRID. Available at: https://ekogridtest.ekogrid.fi/blog/canada/ (Accessed on 8.11.2023).

Meng, F., Li, Y., & Zhou, Z. (2017). Advances in understanding and engineering biosynthesis of isoprenoids. Synthetic and Systems Biotechnology, 2(1), 17-25 (Accessed on 16.2.2024).

Pennsylvania Department of Health. (2021). What can BTEX compounds do to me? Retrieved from https://www.health.pa.gov/topics/Documents/Environmental%20Health/BTEX.pdf (Accessed on 16.04.2024)

Project Management Institute. (2017). A Guide to the Project Management Body of Knowledge (PMBOK Guide). Project Management Institute. (Accessed on 23.2.2024)

Priya, A. (2021). Case Study Methodology of Qualitative Research: Key Attributes and Navigating the Conundrums in Its Application. Sociological Bulletin, 70(1), 94-110. Available at: https://doi.org/10.1177/0038022920970318 (Accessed on 30.1.2024).

Rosenbaum, U., Chen, W., Zhang, W., Zappala, S., Bempah, C. K., Gathumbi, S. M., ... & Rinklebe, J. (2020). Soil Contamination with Trace Elements and Organic Pollutants at the Interface of the Food Chain: A Comprehensive Review of the State of the Science. Earth-Science Reviews, 203, 103126 (Accessed on 14.03.2024)

Sam, K., & Zabbey, N. (2018). "Contaminated land and wetland remediation in Nigeria: Opportunities for sustainable livelihood creation." *Science of The Total Environment, 639*, 1560-1573. (Accessed on 3.1.2024)

Sam, K. (2022). "Contaminated land management policy transfer: Drivers and barriers within the Nigerian context." *African Journal of Environmental Science and Technology, 16*(9), 320-334. Available at: https://doi.org/10.5897/ajest2020.2924 (Accessed on 3.1.2024)

Sam, K., Zabbey, N., & Onyena, A. P. (2022). "Implementing contaminated land remediation in Nigeria: Insights from the Ogoni remediation project." *Land Use Policy, 115*, 106051. Available at: https://doi.org/10.1016/j.landusepol.2022.106051 (Accessed on 15.12.2023)

Schwalbe, K. (2019). Information Technology Project Management. Cengage Learning (Accessed on 23.2.2023).

Smith, N. J. (2018). Project Management: A Managerial Approach. John Wiley & Sons (Accessed on 23.2.2023)

Stenuit, B., Agathos, S. N., & Johnson, D. R. (2017). Resilience of Microbial Systems to Chemical Disturbance. In Chemical Bioavailability in Terrestrial Environment (pp. 43-62). Springer, Cham. (Accessed on 28.2.2024)

Takahashi, A. R., & Araujo, L. (2019). Case study research: Opening up research opportunities. *RAUSP Management Journal, 55*(1), 100-111. Available at: https://doi.org/10.1108/rausp-05-2019-0109 (Accessed on 30.1.2024)

UNEP. (2017, August 7). "UNEP Ogoniland oil assessment reveals extent of environmental contamination and threats to human health." Available at: https://www.unep.org/news-and-stories/story/unep-ogoniland-oil-assessment-reveals-extent-environmental-contamination-and (Accessed on 26.12.2023)

Wang, X., Lai, C. M., Li, X., Hapuarachchi, H. C., & Xu, C. Y. (2019). Machine learning approaches for spatial prediction of soil organic carbon stock in Jiangxi Province, China. Journal of Environmental Management, 231, 614-624. Available at: https://doi.org/10.1016/j.jenvman.2018.10.079 (Accessed on 5.2.2024)

Yan, A., Wang, Y., Tan, S. N., Mohd Yusof, M. L., Ghosh, S., & Chen, Z. (2020). Phytoremediation: A promising approach for Revegetation of heavy metal-polluted land., *Frontiers in Plant Science 11*. Avalable at: https://doi.org/10.3389/fpls.2020.00359 (Accessed on 30.1.2024)

Zabbey, N., Sam, K., & Onyebuchi, A. T. (2017). "Remediation of contaminated lands in the Niger delta, Nigeria: Prospects and challenges." *Science of The Total Environment, 586*, 952-965. Available at: https://doi.org/10.1016/j.scitotenv.2017.02.075 (Accessed on 10.12.2023)