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Theoretical Study and Design of Industrial Residue-Based "*Nick-Absorb*" Modular Brick Biofilter for Heavy Metal Mitigation in Runoff Water

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ARTICLE INFO	ABSTRACT
Article History: Accepted: 25 August, 2026 Approved: 20 October, 2026 Published: 31 October, 2026 Keywords: biochar; zeolite; industrial residue; runoff water; environmental mitigation	The increase in nickel industry activity produces residues such as <i>fly ash</i> and <i>slag</i> as well as runoff that have the potential to carry heavy metals into the environment. This condition requires a mitigation approach that can be placed on the runoff path while reusing the remaining material. This study aims to design and analyze the <i>Nick-Absorb concept</i> theoretically as a modular biofilter brick based on industrial waste to mitigate heavy metals (<i>Ni</i> , <i>Cr</i> , <i>Fe</i>) in nickel industry runoff. This study uses a qualitative descriptive method with an <i>engineering design approach</i> based on literature studies and secondary data analysis. The research period was carried out from February to May 2026 at Campus II UIN Alauddin Makassar by focusing on a case study in the PT Indonesia Morowali Industrial Park (IMIP) area. The research sample consisted of secondary data on material characteristics (<i>fly ash</i> , nickel <i>slag</i> , coconut shell biochar, and zeolite) as well as literature on heavy metal mitigation mechanisms. The design results produced a modular biofilter brick concept with a theoretical composition of 25% <i>fly ash</i> , 25% nickel <i>slag</i> , 25% coconut shell biochar, and 25% zeolite. The system is designed through three integrated mechanisms: physical filtration to retain sediment, adsorption by biochar, and ion exchange by zeolite. From an Islamic perspective, this design is a form of effort to minimize environmental damage according to QS. Ar-Rum/30:41. In conclusion, the <i>Nick-Absorb conceptual design</i> theoretically has the potential to be an alternative passive and modular mitigation technology that supports green industry, although the effectiveness of quantitative heavy metal reduction still requires experimental validation in the future .
Kata Kunci: biochar; zeolit; residu industri; air limpasan; mitigasi lingkungan	Peningkatan aktivitas industri nikel menghasilkan residu seperti <i>fly ash</i> dan <i>slag</i> serta air limpasan yang berpotensi membawa logam berat ke lingkungan. Kondisi tersebut memerlukan pendekatan mitigasi yang dapat ditempatkan pada jalur limpasan sekaligus memanfaatkan kembali sisa material. Penelitian ini bertujuan untuk merancang dan menganalisis konsep <i>Nick-Absorb</i> secara teoritis sebagai bata biofilter modular berbasis limbah industri untuk mitigasi logam berat (<i>Ni</i> , <i>Cr</i> , <i>Fe</i>) pada air limpasan industri nikel. Penelitian ini menggunakan metode deskriptif kualitatif dengan

pendekatan *engineering design* berbasis studi literatur dan analisis data sekunder. Waktu penelitian dilaksanakan pada Februari hingga Mei 2026 di Kampus II UIN Alauddin Makassar dengan mengambil fokus studi kasus pada kawasan PT Indonesia Morowali Industrial Park (IMIP). Sampel penelitian berupa data sekunder karakteristik material (*fly ash*, *slag* nikel, biochar tempurung kelapa, dan zeolit) serta literatur mekanisme mitigasi logam berat. Hasil perancangan menghasilkan konsep bata biofilter modular dengan komposisi teoritis 25% *fly ash*, 25% *slag* nikel, 25% biochar tempurung kelapa, dan 25% zeolit. Sistem dirancang melalui tiga mekanisme terintegrasi: filtrasi fisik untuk menahan sedimen, adsorpsi oleh biochar, serta pertukaran ion oleh zeolit. Dari perspektif Islam, rancangan ini menjadi bentuk ikhtiar meminimalkan kerusakan lingkungan sesuai QS. Ar-Rum/30:41. Kesimpulannya, rancangan konseptual *Nick-Absorb* secara teoritis berpotensi menjadi alternatif teknologi mitigasi pasif dan modular yang mendukung industri hijau, meskipun efektivitas penurunan logam berat secara kuantitatif tetap memerlukan validasi eksperimental di masa mendatang.

INTRODUCTION

The development of the nickel downstream industry in Indonesia is progressing rapidly in line with the increasing demand for nickel for *stainless steel* and energy technology. Indonesia holds a strategic position in the global nickel supply chain, while areas such as PT Indonesia Morowali Industrial Park (IMIP) are developing as one of the main centers for nickel processing and refining in Indonesia. This study positions the development of these industrial areas as part of increased production activity and the emerging need for sustainable industrial residue and environmental management. Data in *the IMIP Sustainability Report 2023* also shows that records in a region cover various environmental, social, and governance aspects of companies operating within the area (IMIP, 2023) .

The increase in nickel processing activities in industrial areas is accompanied by the presence of various residues, including *fly ash* , slag, and runoff that need to be managed properly. Runoff is a concern because rainwater flowing through industrial areas and exposed materials can carry particles and dissolved substances to drainage systems and water bodies. Nickel processing and conversion activities produce industrial residues that have the potential to carry metals such as nickel (Ni), chromium (Cr), and iron (Fe), especially when the material comes into contact with rainwater and leaching processes. Recent studies in the IMIP area also show a relationship between the expansion of nickel processing and changes in coastal water quality around the area. Herho et al., (2026) through satellite time series analysis and *Bayesian structural time series* found a decrease in coastal water clarity that was causally related to the expansion of nickel shipments in IMIP.

This situation demonstrates the importance of a mitigation approach that focuses not only on waste treatment after it is formed but also on its placement in waterways before runoff reaches

the receiving environment. Residue material management is also a crucial part of this approach. Wang et al. (2024) explain that the use of value-added *fly ash* can be directed towards the development of materials such as silica, alumina, and zeolite, so that their use can contribute to reducing environmental pressure while increasing the waste's utility.

In addition to utilizing waste materials, the use of adsorbent media is a relevant approach in controlling heavy metals. Biochar has a porous structure and surface functional groups that allow for interaction with metal ions. Gao et al., (2023) showed that biochar-based materials can bind Ni through several mechanisms, including physical and chemical adsorption, electrostatic interactions, ion exchange, and coordination. The study also showed that the characteristics of the pore structure and surface area affect the material's ability to adsorb Ni. The use of biochar from coconut shell waste has also been studied as a form of utilizing biomass as an adsorbent material, thus supporting the use of local resources in the development of functional materials.

Zeolite is used as a supporting material because it has a porous structure and ion exchange capabilities. Elkhatib et al., (2024) showed that zeolite-based materials can be used for remediation of industrial waste air containing metals through an absorption process, with performance influenced by conditions such as pH, initial concentration, contact time, and adsorbent dosage. These findings support the use of zeolite as one of the active components in the Nick-Absorb design, especially to complement the function of biochar which acts as an adsorption medium. In this study, the combination of these materials was placed together with *fly ash* and nickel slag so that the function of the material is not only directed at protecting contaminants, but also at the formation of a biofilter unit that has structural and filtration functions.

Although the ability of biochar, zeolite, and *fly ash -based materials* in pollutant management is well known, a relevant challenge for application in industrial areas is how these materials are integrated into a simple, modular system that can be placed in the runoff path. This study identified that the use of adsorbent media in powder or granular form requires a separate container or installation, so a form that is more easily absorbed by the drainage system is needed. Based on this need, Nick-Absorb was designed as a modular *brick biofilter that combines fly ash* and nickel slag as waste-based components, coconut shell biochar as an adsorbent medium, and zeolite as an ion exchange medium. The composition design consists of 25% *fly ash* , 25% slag, 25% coconut shell biochar, and 25% zeolite.

Nick-Absorb is designed to be placed in drainage channels or runoff points . As runoff passes through the module, particles and sediments first undergo physical filtration through the porous structure, then dissolved contaminants interact with biochar through adsorption and with zeolite through ion exchange. This design integrates three main functions: physical filtration,

adsorption, and ion exchange, in a single modular unit. With this approach, Nick-Absorb not only utilizes waste materials and biomass as sources but also modifies them to become part of the runoff management system.

The development of environmental mitigation technology is also relevant to Islamic values. The Quran positions environmental damage as a problem related to human actions. Allah SWT says in Surah Ar-Rum/30:41:

ظَهَرَ الْفَسَادُ فِي الْبَرِّ وَالْبَحْرِ بِمَا كَسَبَتْ أَيْدِي النَّاسِ لِيُذِيقَهُمْ بَعْضَ الَّذِي عَمِلُوا لَعَلَّهُمْ يَرْجِعُونَ

Translation:

41. Corruption has appeared on land and sea because of what the hands of men have earned. Allah will make them taste some of their deeds, so that they may return (to the right path).

The verse provides an ethical basis that human activities need to be accompanied by responsibility towards the environment and efforts to prevent damage. The study of the concept of *caliph* and *amanah* in environmental management also places humans as parties who have the responsibility to maintain the balance and desires of the earth. In this study, these values are realized at the context level through the reuse of waste materials and the development of a runoff mitigation system, while the technical effectiveness of Nick-Absorb remains determined based on material mechanisms and scientific validation. Based on this description, this article aims to design and analyze the concept of Nick-Absorb as a modular biofilter brick based on industrial waste for mitigating heavy metals in nickel industry runoff through the integration of physical filtration, biochar adsorption, and zeolite ion exchange.

METHOD

This study uses a qualitative descriptive method with an *engineering design approach* based on theoretical studies and secondary data analysis. This approach is used to integrate material characteristics, the function of each component, contaminant removal mechanisms, and the need for implementing a passive filtration system into a *Nick-Absorb modular biofilter brick technology plan* as a heavy metal mitigation system (*Ni*, *Cr*, *Fe*) in nickel industry runoff water. This study focuses on conceptual *engineering design* through a theoretical study approach and does not include direct physical laboratory testing.

The research was conducted for four months, from February to May 2026. Literature search, secondary data collection, material characteristic analysis, and design planning were conducted at Campus II of UIN Alauddin Makassar, while the operational area of PT Indonesia Morowali Industrial Park (IMIP), Central Sulawesi, was used as a case study context for the

application of *Nick-Absorb* in the nickel industrial area. The population and sample of this research were not humans or respondents, but rather the materials that make up *Nick-Absorb* and scientific information that supports the design process, namely *fly ash*, *nickel slag*, *coconut shell biochar*, and *zeolite*, as well as information regarding the characteristics of nickel industrial runoff water, adsorption mechanisms, and ion exchange.

The data collection method was carried out using *a purposive document review*, where secondary data were obtained through literature studies and documentation of scientific journals, scientific books, official documents, and regulations related to environmental management and wastewater quality standards. Data collection was carried out by selecting literature based on its suitability to the characteristics of the material, its function in the filtration system, the mitigation mechanism of heavy metals, and the design requirements of the biofilter brick.

The instruments used in data collection and processing are documentation sheets and literature matrix analysis to record the type of material, physical and chemical characteristics, material function, heavy metal removal mechanism, and its relevance to the *Nick-Absorb design*. In addition, computer devices and document processing and design software are used to organize data and compile a *brick biofilter concept plan* in the form of academic flow diagrams and schematic illustrations.

The research procedure was carried out through the stages of problem identification, literature study, analysis of material characteristics and functions, composition preparation, modular form design, and analysis of working mechanisms and application potential. These stages refer to the design process starting from the identification of nickel industry runoff water characteristics, adsorption and ion exchange mechanisms, to conceptual product design. Based on the results of the analysis and material function characteristics, *Nick-Absorb* was designed using a theoretical composition of 25% *fly ash*, 25% *nickel slag*, 25% *coconut shell biochar*, and 25% *zeolite*. *Fly ash* and *nickel slag* were placed as waste-based materials that support the initial structure and filtration, *coconut shell biochar as an adsorption medium*, and *zeolite as an ion exchange medium*.

Data analysis techniques were conducted descriptively, qualitatively, and comparatively by linking the characteristics of each material with its function and working mechanism within the system. The *Nick-Absorb mechanism* is explained through three integrated stages: physical filtration to retain particles and sediment, adsorption by *biochar* of contaminants on the material surface, and ion exchange by *zeolite*. The analysis results were then used to assess the suitability of the design, material function, mitigation mechanism, modularity, and potential application of *Nick-Absorb* in industrial area drainage systems.

RESULTS

The design resulted in the *Nick-Absorb concept* , a modular *brick biofilter* designed as a passive filtration unit for placement in runoff channels in nickel industrial areas. The system consists of porous brick modules that can be installed in drainage channels, surface flow paths, or specific points serving as runoff channels. The modular configuration allows for phased installation according to site requirements and simplifies partial unit replacement if necessary.

Nick-Absorb 's components consist of 25% *fly ash* , 25% *nickel slag* , 25% *coconut shell biochar* , and 25% zeolite. This composition is designed based on the functions assigned to each material. *Fly ash* and *nickel slag* are used as waste-based components that support the formation of the brick structure and the initial filtration process. *Coconut shell biochar* is placed as an active component for the adsorption process, while zeolite is used as a component that supports the ion exchange process. The integration of these four materials produces a filtration medium that not only functions physically, but also combines structural functions and chemical contaminant processing in one modular unit.

Figure 1. Nick-Absorb Flow Diagram



Nick-Absorb works in stages through a combination of physical and chemical filtration. Stage 1: Physical Filtration: When runoff water enters the surface of the biofilter brick, mud

particles, industrial dust, and sediment are retained in the initial layer of porous material. The brick's hollow structure helps slow the water flow, extending its contact time with the adsorbent medium.

Stage 2: Heavy Metal Adsorption: After the initial filtration stage, heavy metal ions are absorbed by the biochar through surface adsorption. The active functional groups in the biochar bind heavy metal ions through electrostatic interactions and chemical complexation.

Stage 3: Ion Exchange: In the next stage, zeolite undergoes an ion exchange process, replacing heavy metal ions in the water with natural ions such as Na^+ , K^+ , and Ca^{2+} . This process traps heavy metals within the zeolite's mineral structure, reducing pollutant concentrations.

Stage 4, Outflow of Water Water that has gone through the entire filtration process then exits the system with a lower contaminant content before being flowed into the environment around the industrial area.

Table 1. Composition and function of Nick-Absorb ingredients

Design components	Composition	Functions in Nick-Absorb
Fly Ash	25%	Initial binder/filtration
Nickel slag	25%	Structural Reinforcement
Coconut shell biochar	25%	Active adsorbent
Zeolite	25%	Ion exchange media

Nick-Absorb design is characterized by a passive, modular, and partially maintainable system. This system works passively utilizing gravity and the natural flow of runoff water without requiring electrical energy or additional mechanical devices. Its modular design provides installation flexibility at various drainage channel points and facilitates individual unit replacement when media saturation occurs. In addition to its pollution mitigation function, the *Nick-Absorb* concept significantly supports the reuse of industrial residues (*fly ash* and nickel slag) and biomass waste (coconut shell biochar), thus integrating green industry and circular economy principles into functional products.

Overall, the results of this design prove that *Nick-Absorb* can be formulated as a modular biofilter unit that integrates three sequential mitigation functions, namely physical filtration of particles/sediments, adsorption by *biochar* , and ion exchange by zeolite. However, because this research is at the conceptual design stage , the determination of the quantitative efficiency of reducing the concentration of *Ni*, *Cr*, and *Fe* metals as well as the saturation capacity of the media still requires experimental testing and validation in further research .

DISCUSSION

1. Analysis of Material Composition and Design Rationality

Nick-Absorb design demonstrates an integrative approach in developing a modular *brick biofilter system* for heavy metal mitigation in nickel industry runoff. This system combines *fly ash* and nickel *slag* as waste-based materials, coconut shell *biochar* as an adsorption medium, and zeolite as an ion exchange medium. The design composition is set proportionally at 25% *fly ash* , 25% nickel *slag* , 25% coconut shell *biochar* , and 25% zeolite. The selection and determination of the proportions of these materials not only consider the specific functions of each component but are also directed at producing an integrated filtration unit that includes structural functions, physical filtration, and chemical contaminant treatment. *Fly ash* is utilized as part of the matrix-forming material and initial filtration, while nickel *slag* functions as a coarse aggregate and brick structural reinforcement. On the other hand, *biochar* and zeolite are placed as active media that interact directly with heavy metal ions as runoff flows through the system.

The use of *fly ash* and nickel *slag* in the *Nick-Absorb design* provides significant added value to industrial residue management. Wang et al., (2024) explained various opportunities for value-added utilization of *fly ash* , so that the material does not always have to be positioned as ultimate waste , but can be developed into a functional raw material for more productive applications. In this design, this principle is applied by making *fly ash* a component of the biofilter brick matrix. In addition, nickel *slag* functions as an aggregate and brick structural reinforcement, so that the residue from the nickel smelting process has a new function in environmental mitigation infrastructure. The use of *slag* as a functional material is highly relevant to the challenges of hazardous waste management in the nickel mining and processing industry in Indonesia as reviewed by Ressa et al., (2024). However, the function of *fly ash* and *slag* in this design needs to be clearly distinguished from the function of the active adsorbent media. This study places both residues primarily as structural components and supports for physical filtration, while the binding process of heavy metal ions is more borne by *biochar* and zeolite. This functional distinction is crucial because the characteristics of industrial waste can vary significantly depending on the source and production process. Therefore, the presence of *fly ash* and *slag* in *Nick-Absorb* cannot be used as a basis for claiming that they have specific adsorption capacities for Ni, Cr, or Fe. Although Yadav et al., (2023) demonstrated the use of *fly ash -based materials* for the treatment of heavy metal-laden wastewater, and Praipipat et al., (2023) demonstrated the potential of *fly ash* and zeolite-based materials for Pb adsorption, these findings in the context of this study serve as a theoretical basis for supporting waste utilization and cannot

be directly equated with the actual performance of fly ash and slag in Nick-Absorb without further testing.

biochar plays a very specific and crucial role as an adsorption medium in the Nick-Absorb system. This biomass was selected based on its porous structure, high specific surface area, and abundance of active functional groups on its surface, which allow for chemical interactions with contaminant ions. Pratama et al., (2025) demonstrated the effectiveness of utilizing coconut shell biochar as a reliable adsorbent, while Choiri et al., (2025) successfully developed a permeable reactive barrier based on coconut shell biochar with cement adhesive for the remediation of water contaminated with Pb^{2+} ions. These previous findings provide strong scientific justification for the selection of coconut shell as a biochar precursor in Nick-Absorb. In addition, Gao et al., (2023) demonstrated that biochar-based materials are able to interact effectively with nickel (Ni) ions through various mechanisms, including physical and chemical adsorption, electrostatic interactions, ion exchange, and surface complexation. However, the research results cannot be directly used to determine the absolute adsorption capacity of coconut shell biochar on Nick-Absorb, considering the differences in raw material variations, pyrolysis methods, physicochemical characteristics of biochar, environmental conditions, and the water matrix tested.

biochar performance, zeolite is presented to optimize the contaminant removal process through an ion exchange mechanism. The porous aluminosilicate framework structure of zeolite minerals allows for cation substitution between natural ions present in the zeolite structure and dissolved heavy metal ions in runoff water solutions. Elkhatib et al., (2024) confirmed that nanoparticle-based zeolite materials are highly efficient for the remediation of contaminated industrial wastewater through a synergistic combination of surface adsorption and ion exchange. Similarly, a study by Praipipat et al., (2023) demonstrated the high adsorption capacity of modified zeolite materials for heavy metals. This series of literature provides a solid scientific basis for the placement of zeolite as an active component of Nick-Absorb. However, differences in the types of target metal ions, the specific characteristics of zeolite media, and the hydrological conditions of runoff water in the field still require specific validation of actual performance.

2. System Working Mechanism, Modularity, and Integration of Environmental Ethics

The combination of these four main materials results in a system working mechanism that occurs sequentially through three main stages: physical filtration, chemical adsorption, and ion exchange. In the initial contact phase, the porous matrix structure of the biofilter brick is designed to retain suspended particles such as mud, industrial dust, and fine sediment carried by the runoff

flow, while also functioning to slow the hydraulic rate of the water flow. After passing through the physical filtration zone, the runoff water comes into contact with the active surface of the *biochar* so that dissolved contaminants undergo a surface adsorption process, before the water flow finally passes through the zeolite component that facilitates the exchange of heavy metal cations. This series of configurations provides a conceptual advantage for multimaterial systems because the pollution control process does not rely solely on a single mechanism. However, claims that this combination of materials is superior or more effective still remain at the level of theoretical hypothetical design, considering that quantitative measurements of heavy metal concentrations have not been directly carried out before and after passing through the media. Therefore, it is more objectively and scientifically correct to state that *Nick-Absorb* is designed to combine potentially complementary mechanisms, but its exact removal efficiency still requires empirical proof.

brick design is one of the conceptual novelties promoted in this design. *Nick-Absorb* is designed to be applied directly to industrial drainage channels, *runoff paths*, and critical points of rainwater runoff, allowing the mitigation process to run passively without the need for additional electrical energy or complex mechanical installations. This modular nature allows for gradual installation of units and flexibility to adjust the dimensions and geometry of the channels in the field. If a module experiences a decline in function or media saturation, it can be partially removed and replaced (*individual replacement*) without having to dismantle the entire surrounding drainage network construction. However, various technical parameters such as permeability, infiltration rate, contact residence time, pore size distribution, sediment accumulation rate, and the mechanical strength of the brick structure still require comprehensive testing before its operational excellence is proven in the field.

The utilization of industrial residues and biomass waste in the development of *Nick-Absorb* is in line with the paradigms of green industry and circular economy. Ghisellini et al., (2016) defines a circular economy as a socio-economic approach that seeks to maintain the utility value of resources and materials for as long as possible by minimizing the input of new materials and optimizing waste reuse. Within the *Nick-Absorb framework*, the utilization of *fly ash* and *nickel slag* as structural raw materials, and coconut shells as *biochar precursors*, reflects efforts to transform production waste into functional, useful products. However, this design cannot yet be categorized as a complete circular economy implementation because it is not accompanied by a life cycle analysis (*LCA*), *energy evaluation*, *saturated media regeneration method*, and *post-use biofilter* waste management protocol. Therefore, this research contribution is more appropriately positioned as a conceptual initial step in converting industrial residues and biomass

into functional materials for environmental mitigation systems.

This aspect of technological design is also closely related to the theological values and environmental ethics of Islam, particularly regarding the prohibition of causing damage on earth. Allah SWT says in QS. Ar-Rum verse 41: "*Corruption has appeared on land and in the sea because of what the hands of men have earned...*". In interpreting this verse, Quraish Shihab through *Tafsir Al-Mishbah* explains that the word *zhahara* indicates a phenomenon that is clearly visible and widespread, while the word *fasa*, referring to Al-Ashfahani's view, is interpreted as the departure of something from its original state of balance, whether in social, physical, or ecological dimensions. The mention of the words "land" and "sea" simultaneously in this verse can be understood as a representation of the ecosystem that is both the location and object of impact from destructive human activities, such as water pollution due to industrial waste that causes a decline in the quality of the terrestrial and coastal environment. Quoting the view of Ibn 'Assyur, Shihab emphasizes that the universe was created by Allah in a harmonious and balanced system, but bad human intervention can cause ecological dysfunction that ultimately brings disaster to human life itself. Allah's warning that humans feel some of the consequences of their actions is intended as an instrument of awareness so that they return to the right path (*lâ'allahum yarji'ûn*). This theological understanding is very relevant to reflect on the problem of waste and runoff from the nickel industry which has the potential to degrade the quality of the terrestrial and aquatic environment, so that efforts to design mitigation technology based on the reuse of waste residues are a real manifestation of human efforts to restore the balance of disturbed ecosystems.

3. Limitations of the Design and Prospects for Further Research

Although supported by a comprehensive theoretical basis and mechanistic synthesis, this study has fundamental limitations because it has not involved experimental testing in the laboratory. The absence of empirical data on the concentrations of *Ni*, *Cr*, and *Fe metals* before and after passing through the biofilter module means that the removal *efficiency*, maximum adsorption capacity, breakthrough time, and media service life cannot be determined quantitatively. The design composition of 25% *fly ash*, 25% nickel *slag*, 25% *biochar*, and 25% pure zeolite is a theoretical proportion resulting from a literature review, not an empirical optimal composition obtained through experimental optimization. In addition, the use of industrial residues as construction raw materials must always be aware of the potential for leaching of secondary heavy metals. Therefore, testing the characteristics of the *Toxicity Characteristic Leaching Procedure* (TCLP) is placed as an absolute prerequisite to ensure that the use of *fly ash* and *slag* does not trigger secondary pollution in the environment. Based on these various

limitations, a series of urgent follow-up research agendas that need to be carried out include in-depth tests of the physical-chemical characteristics of the material, leaching tests (*TCLP test*), *permeability and mechanical strength tests of bricks*, *laboratory column adsorption capacity tests*, and *field pilot scale* prototype trials to validate the safety, durability, and operational feasibility of *Nick-Absorb* in real terms before being applied en masse.

CONCLUSION

Nick-Absorb is a modular *brick biofilter design* that integrates *Fly Ash* , nickel slag, coconut shell biochar, and zeolite for heavy metal mitigation in nickel industry runoff. This design combines physical filtration, adsorption, and ion exchange in one system, while reusing industrial residues and biomass as functional materials. This approach demonstrates the potential of *Nick-Absorb* as an alternative modular and passive mitigation technology and supports the principles of green industry and circular economy. The integration of Islamic values through QS. Ar-Rum/30:41 provides an ethical basis that the use of resources and human activities must be accompanied by responsibility to prevent environmental damage.

Nick-Absorb in this study is still in the conceptual planning stage so its effectiveness in reducing Ni, Cr, and Fe cannot be quantitatively determined. The implication of this study is the availability of a basic plan that can be developed into a biofilter prototype for nickel industry runoff management. Further research is recommended to conduct experimental testing, optimization of *brick composition and configuration* , testing of heavy metal *removal efficiency* , hydraulic characteristics, material durability, and *leaching potential* to ensure the safety and feasibility of *Nick-Absorb* before being applied in field conditions.

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