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TECHNOLOGY FOR TREATING INDUSTRIAL WASTEWATER IN PETROLEUM AND CHEMICAL INDUSTRIES

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Abstract - *Typically, wastewaters discharged from petroleum industries contain hydrocarbons and suspended solids in various forms such as solutions, colloids, and particles. Treating this type of wastewater is crucial but must be done cost-effectively using electro-coagulation instead of traditional chemical treatments like conventional coagulation-flocculation processes or direct re-injection into oil wells. Electro-coagulation separates two phases via settling or flotation and produces similar results to coagulation-flocculation processes that use reagents such as FeCl3 or Al2(SO4)3; however, the coagulant used in electro-coagulation is derived from anodic dissolution of Aluminum. In our study on process efficiency for Oil and Wastes Removal Efficiency (OWRE), we evaluated several parameters including solution pH levels, current intensity rates, and clarification times. Our findings showed OWRE was 79.61% for both current intensities of 0.3A and 0.65A under medium basic solution pH conditions ranging between 9-11 after respectively clarifying for 100 minutes and 80 minutes. To evaluate the impact on vegetation growth following treatment processing with irrigation testing conducted over thirteen months utilizing two types of plants - date palm trees and shaft apocalyptic plants - we observed that fine dune sand with a thickness layer measuring at least five centimeters effectively removed most remaining oil deposits while playing an essential role as biological filters surrounding basin areas where layers were replaced every three months. The results indicate little garden plants appeared healthy with normal growth patterns unaffected by any contaminants present within treated water samples subjected to our experimental procedures thus far conducted successfully without adverse effects upon local ecosystems or wildlife populations nearby HBK's petroleum region facilities' operating areas where they have implemented environmentally-friendly practices towards sustainable operations aimed at minimizing their ecological footprint while maximizing production efficiencies simultaneously promoting social responsibility awareness among stakeholders involved in these projects across various sectors globally today.*

***Key Words*:** Industrial wastewater treatment, Petroleum industry, Chemical industry, Biological treatment, Ion exchange.

1.BACKGROUND OF INDUSTRIAL WASTEWATER IN PETROLEUM AND CHEMICAL INDUSTRIES

Industrial wastewater in petroleum and chemical industries is a complex mixture of contaminants generated throughout various processes. In petroleum refining, the separation of crude oil into different products yields wastewater laden with hydrocarbons, heavy metals, and organic compounds. Additionally, processes like desalting and oil-water separation contribute to the wastewater stream. Chemical manufacturing further compounds the issue with diverse chemical reactions producing wastewater containing organic and inorganic compounds, acids, bases, and heavy metals. Cleaning and maintenance activities, as well as cooling water systems, also add to the wastewater load, often containing solvents, detergents, and chemicals. Common contaminants include hydrocarbons, heavy metals like mercury and chromium, toxic chemicals such as benzene and chlorinated compounds, as well as salts and inorganic compounds. The environmental impact of untreated wastewater can be severe, posing risks to aquatic ecosystems, soil quality, and groundwater resources. Hence, stringent wastewater treatment measures, including physical, chemical, and biological processes, are imperative to mitigate environmental pollution and comply with regulatory standards, ensuring the protection of both the environment and human health.

2.IMPORTANCE OF EFFECTIVE WASTEWATER TREATMENT

Effective wastewater treatment is imperative for safeguarding public health, preserving ecosystems, and promoting sustainable development. By removing harmful pathogens, chemicals, and pollutants, wastewater treatment prevents the spread of waterborne diseases and protects the health of communities. Moreover, treated wastewater ensures the integrity of aquatic ecosystems by minimizing pollution and preserving biodiversity. It also supports resource conservation efforts by facilitating water reuse and reducing freshwater demand. Compliance with regulatory standards is essential, avoiding legal repercussions and promoting responsible resource management. Additionally, effective wastewater treatment contributes to the sustainability of agricultural practices, protects downstream

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users, and enhances water quality for recreational and economic purposes. Overall, investing in wastewater treatment infrastructure and technologies is essential for addressing environmental challenges, supporting community well-being, and fostering a sustainable future.

3. CHALLENGES IN INDUSTRIAL WASTEWATER TREATMENT

Industrial wastewater treatment presents a myriad of challenges stemming from the complexity and variability of contaminants, high treatment costs, stringent regulatory requirements, and energy consumption. Industries grapple with the intricacies of managing large volumes of wastewater with diverse compositions while striving to comply with environmental regulations and minimize their ecological footprint. Moreover, the disposal and management of sludge generated during treatment processes pose additional logistical and environmental hurdles. The emergence of new contaminants further complicates the treatment landscape, necessitating ongoing research and innovation. Water scarcity exacerbates these challenges, urging industries to adopt water reuse strategies despite associated costs. Legacy pollution adds another layer of complexity, requiring long-term remediation efforts. Addressing these challenges demands concerted efforts in technological advancement, regulatory enforcement, financial investment, and collaborative partnerships to ensure effective industrial wastewater treatment while safeguarding human health and the environment.

4.ADVANCED TECHNOLOGIES IN WASTEWATER TREATMENT

Advanced technologies play a crucial role in enhancing the efficiency, effectiveness, and sustainability of wastewater treatment processes. Some notable advanced technologies include:

1. **Membrane Filtration:** Membrane technologies such as reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF) are widely used for the removal of suspended solids, pathogens, dissolved salts, and organic compounds from wastewater. These membranes offer high filtration efficiency and can produce high-quality treated water suitable for reuse or discharge.

2. **Advanced Oxidation Processes (AOPs):** AOPs involve the generation of highly reactive hydroxyl radicals to oxidize and degrade organic pollutants in wastewater. Technologies such as ozone-based oxidation, UV-based photolysis, and Fenton's reaction can effectively remove refractory organic compounds, pharmaceuticals, and emerging contaminants from wastewater.

3. **Biological Nutrient Removal (BNR):** BNR processes utilize specialized microbial communities to remove nutrients such as nitrogen and phosphorus from wastewater through biological processes. Enhanced biological phosphorus removal (EBPR) and nitrite shunt processes are examples of advanced BNR technologies that achieve efficient nutrient removal while minimizing chemical usage and sludge production.

4. **Advanced Biological Treatment:** Advanced biological treatment processes such as membrane bioreactors (MBRs), sequencing batch reactors (SBRs), and moving bed biofilm reactors (MBBRs) offer improved treatment efficiency, higher biomass retention, and better solids-liquid separation compared to conventional activated sludge systems. These technologies are particularly effective for treating high-strength industrial wastewater and achieving stringent effluent quality standards.

5. **Electrochemical Treatment:** Electrochemical technologies such as electrocoagulation (EC) and electrooxidation (EO) utilize electrical energy to destabilize and remove contaminants from wastewater through electrochemical reactions. These technologies can efficiently remove heavy metals, organic pollutants, and microorganisms while minimizing chemical usage and sludge generation.

6. **Membrane Distillation (MD):** MD is an emerging membrane-based technology that utilizes the vapor pressure difference across a hydrophobic membrane to separate pure water from wastewater. MD offers advantages such as high rejection of contaminants, low energy consumption, and compatibility with high-salinity and high-temperature wastewater streams.

7. **Advanced Sludge Treatment:** Advanced sludge treatment technologies such as anaerobic digestion, thermal hydrolysis, and sludge dewatering with advanced techniques like centrifugation and belt filter presses improve the dewaterability, stability, and energy recovery potential of sludge produced during wastewater treatment, thereby reducing disposal costs and environmental impacts.

5.METHODOLOGY

In this segment of the methodology, we will scrutinize the approach utilized for managing petrochemical wastewater and identify the key parameters analyzed to evaluate results. A comprehensive account of this chapter is presented below:

6.PARAMETER FOR ANALYSIS

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In this research work, we have taken two parameter for the analysis of the results, the details of the parameter is given below:

1. Potential of Hydrogen
2. Turbidity

6.1.Potential of Hydrogen

The appropriate pH level for wastewater depends on various factors including the source of the wastewater, treatment processes involved, and environmental regulations. However, in general, the recommended pH range for wastewater treatment is typically between 6 and 9.

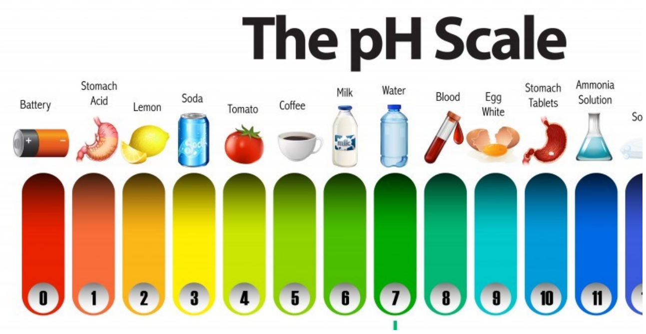

Figure-01: pH

6.2.Turbidity

Turbidity in wastewater, denoting the cloudiness caused by suspended solids, serves as a vital parameter reflecting water quality. Measured in nephelometric turbidity units (NTU), typically using turbidimeters, it indicates pollution levels and aids in regulatory compliance. High turbidity can impede sunlight penetration in aquatic ecosystems, affecting oxygen levels and aquatic life. Employing sedimentation, filtration, and coagulation, treatment processes mitigate turbidity, ensuring environmental and public health safety. Continuous monitoring and adherence to standards are pivotal, ensuring effective wastewater management.

Figure-02: Turbidity

7.METHOD FOR ANALYSIS OF THE RESULT

Electro-coagulation is a promising method for treating petrochemical wastewater by using electrodes to release ions and form aggregates that encapsulate contaminants. These aggregates are then separated from the water using techniques like sedimentation or filtration. The method is versatile across pH ranges and cost-effective, but its efficacy depends on factors like wastewater composition and treatment system design. Integration into a comprehensive wastewater treatment strategy is crucial for environmental compliance and optimal results.

The benefits of electro-coagulation for treating petrochemical wastewater include its effectiveness in removing various contaminants, low operating costs compared to traditional methods, and the ability to function across a wide pH range. However, the efficiency of electro-coagulation can be affected by factors such as wastewater composition, treatment system design, and electrical parameters applied.

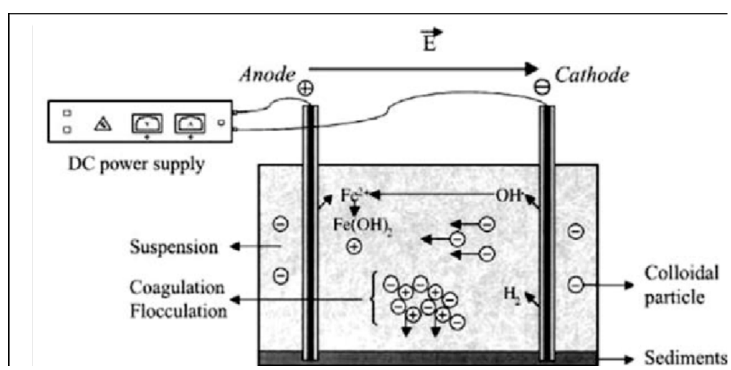

Figure-03: Principle of Electro-coagulation

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8.RESULT AND ANALYSIS

In this section of the Results and Discussion, we will delve into the findings derived from the investigation of petrochemical wastewater through the use of the electro-coagulation method. A detailed and thorough examination of these results will be provided in the subsequent paragraphs. It is important to understand the significance and implications of these outcomes in order to gain a deeper insight into the effectiveness of electro-coagulation in treating petrochemical wastewater.

8.1.Effect of current intensity on the solution pH.

The impact of current intensity on solution pH is a topic of interest in scientific research. The findings reveal that, in general, the pH of the solution tends to increase gradually from an initial weakly acidic value of 6 and eventually reaches neutral or slightly basic levels after a clarification time of 120 minutes. However, when analyzing solutions with lower current intensities (I = 0.25 A), it was observed that the changes in pH were insignificant, as the solution continued to remain weakly acidic throughout the process. These results have important implications for various fields ranging from chemical engineering to environmental science and underscore the importance of carefully controlling current intensity levels during experimentation and practical applications.

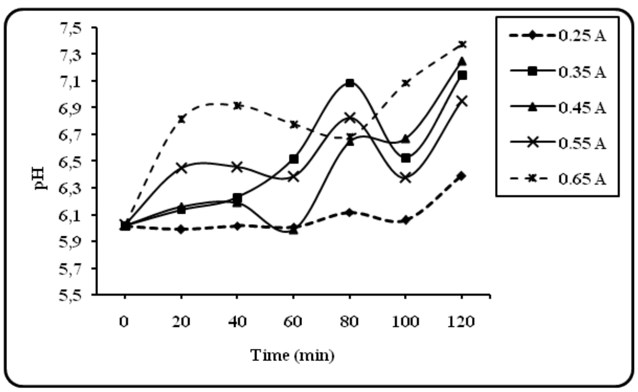

Figure-04: Current Intensity from 0.25A to 0.65A on pH Solution.

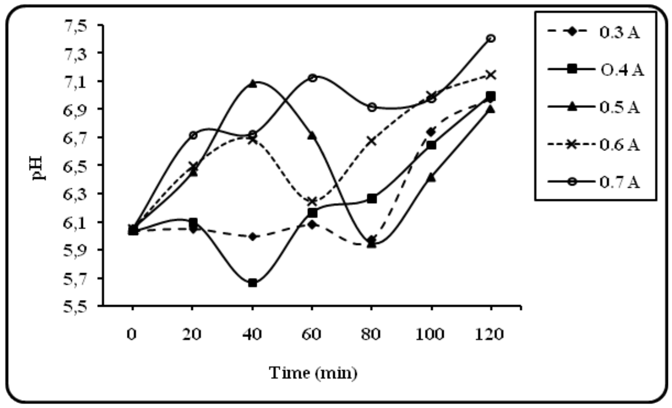

Figure-05: Current Intensity from 0.3A to 0.7A on pH Solution.

When the current intensity is increased, it usually leads to a quicker adjustment of the pH levels. This is because there is an increase in the production of species that have an impact on altering the pH at the electrodes. Therefore, it can be deduced that higher current intensities are directly proportional to a faster rate of pH alteration.

8.2.Effect of current intensity on the Turbidity.

The effect of current intensity on turbidity in aquatic environments is a multifaceted phenomenon. When currents intensify, especially in bodies of water like rivers, lakes, or oceans, they can trigger the resuspension of sediment particles from the bed, significantly elevating turbidity levels. The increased flow creates turbulence, stirring up suspended particles and prolonging their suspension in the water column. Consequently, this agitation contributes to the cloudiness or haziness observed in the water. Additionally, heightened currents often lead to erosion along shorelines and riverbanks, further introducing sediment into the water and exacerbating turbidity. However, it's essential to note that increased current intensity isn't always synonymous with elevated turbidity. In certain instances, intensified currents might enhance mixing within the water column, potentially distributing suspended particles more evenly and mitigating turbidity.

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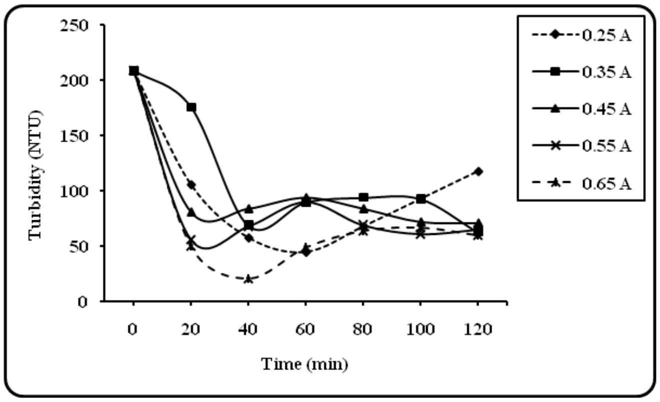

Figure-06: Current Intensity from 0.25A to 0.65A on Turbidity.

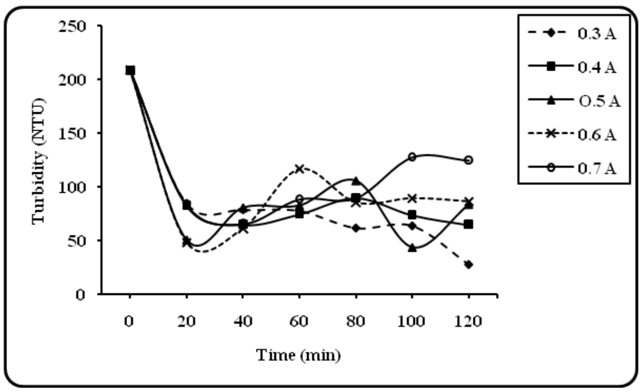

Figure-07: Current Intensity from 0.3A to 0.7A on Turbidity

8.CONCLUSION

To eliminate emulsified oil and waste from wastewater produced by petroleum industries, electro-coagulation flotation treatment was conducted using Aluminum electrodes at a voltage of 12 V and contact time of 120 min. The results were positive, with a reduction of 78.34% in oil and waste achieved using a current intensity of 0.65 A in an environment with solution pH ranging between 4-6 after clarifying for 120 min. Similarly, a reduction of 77.70% was observed when the current intensity was set to 0.3 A in an environment with solution pH ranging between 6-9 after clarifying for the same duration. When the solution pH ranged between (9-11), applying a current intensity of either 0.65 A or .03A resulted in reductions of oil and wastes by up to79.62% and79.61%, respectively; however, different clarification times were required -80 min for the former and100 min for the latter.

Although all four experiments yielded similar turbidity levels, they differed significantly regarding clarification time as well as solution pH level used during treatment process.The last two experiments proved to be more efficient than others since their Oil and Waste Removal Efficiencies were almost identical; however,it is worth mentioning that there are economic implications associated with these findings.To save on electrical energy while sacrificing some processing time requires utilizing lower currents (i.e.,0.3A)in medium-basic environments whereas higher currents(i.e.,0..65A) result in excessive consumption despite saving processing time.Therefore,a trade-off must be made depending on individual preferences.Criteria such as time constraints or cost effectiveness need consideration before deciding which method is best suited to achieve desired outcomes

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