

Resource Recovery from Produced Water by Sequential Dark-Photo Fermentation for Biohydrogen Generation

Nehsoon Tahir Sharif¹, Laraib Fatima¹, Syeda Ayesha Zaidi¹, Umm-E-Kalsoom¹, Abdul-Sattar Nizami^{1*}

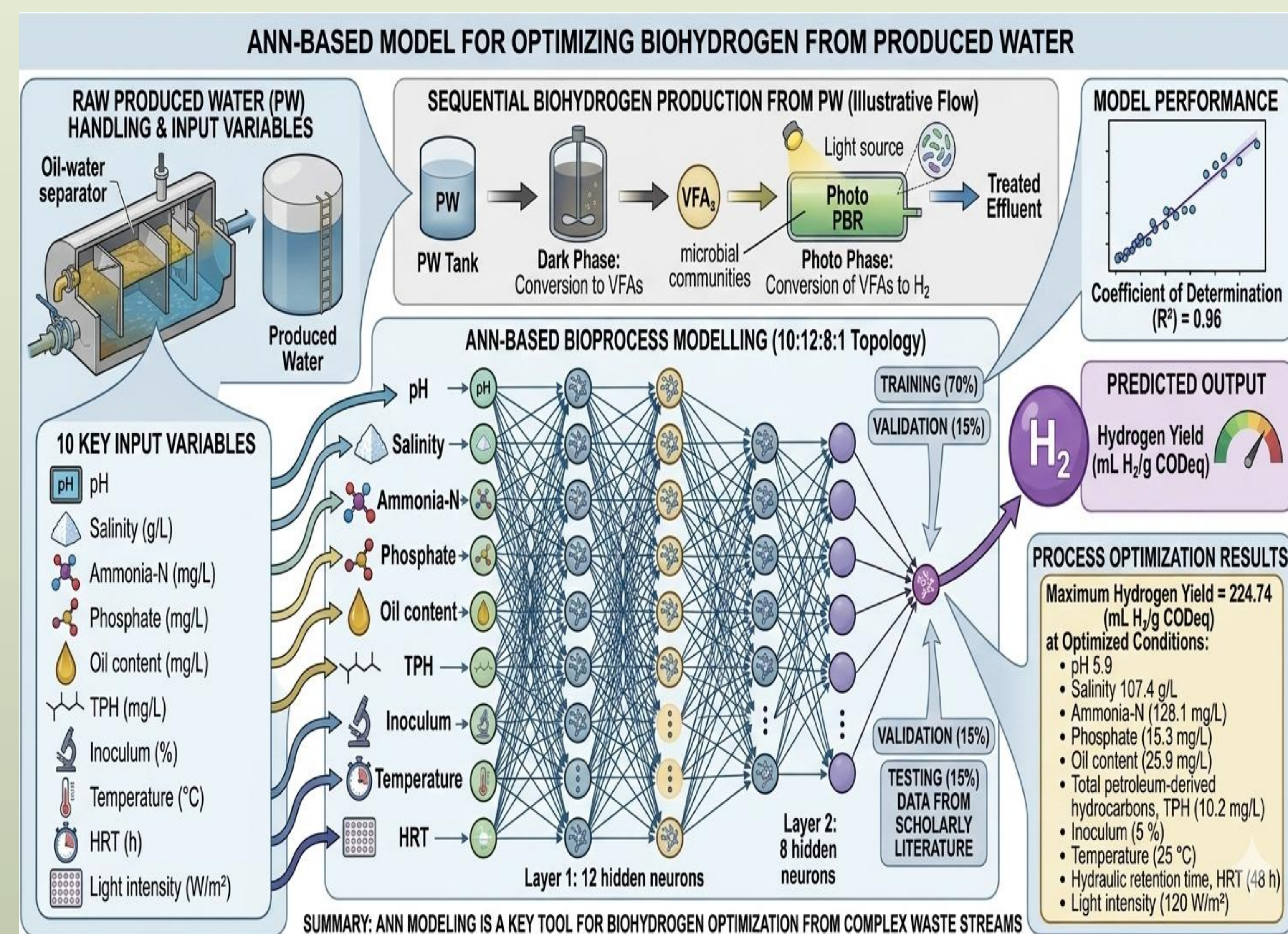
¹Sustainable Development Study Centre (SDSC), Government College University, Lahore 54000, Pakistan

*Correspondence: asnizami@gcu.edu.pk (A.S. Nizami)

Introduction

Artificial Neural Network (ANN) based model is used to investigate biohydrogen production through sequential dark-photo fermentation for modelling and optimization of process. The experimental data used for the purpose of modelling are taken from the existing scholarly literature related to the production of hydrogen from oil-derived wastewater during oil and gas extraction activities. The growing need for clean and renewable energy sources, coupled with the pressure on traditional fossil fuel reserves, has led to an intense search for sustainable energy sources. Oil-producing areas, especially in Gulf countries, face a large amount of Produced Water (PW) and have water scarcity as well. Consequently, PW treatment and valorization by means of biological processes are promising solutions for dual benefits of waste management and renewable energy generation. Sequential dark - photo fermentation is considered as one of the effective biological routes for hydrogen production that involves the significant conversion of organic substrates during dark fermentation and subsequent conversion of volatile fatty acids (VFAs) to hydrogen during photo fermentation. Nevertheless, the nonlinear interactions between microbial communities, operational conditions and physicochemical conditions limit the power of application of conventional kinetic models

Methodological Framework



Results & Discussion

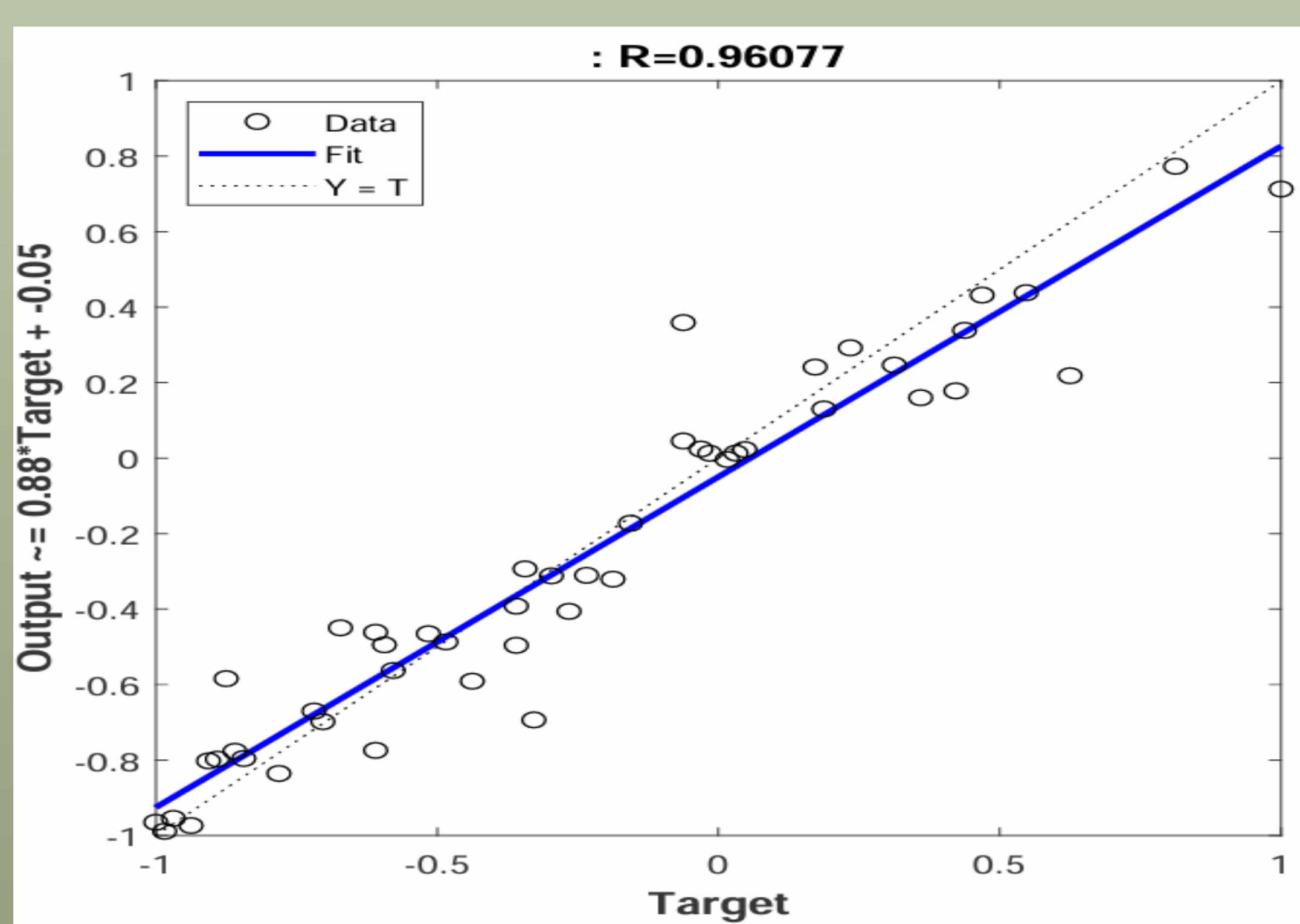


Figure: Overall System Regression

The sequential dark - photo fermentation process shows great potential for biohydrogen manufacturing from produced water. The maximum H₂ yield in the data set was around 224.74 mL H₂/g COD_{eq}, which is a yield comparable to the hydrogen yield values reported in earlier studies devoted to biological hydrogen production from industrial wastewater and organic waste streams. Such results highlight the possibility of our methodology in the larger scheme of green energy recovery of industrial effluents. The implementation of the artificial neural network modelling technique also increases the ability to predict and optimize the production of hydrogen through the determination of the best combinations of the process variables

An extensive regression analysis was carried out to scrutinize the relation between the predicted and the experimentally obtained hydrogen production values. The resulting regression plot showed a strong linear correlation between the results predicted by the ANN and the actual empirical measurements. The calculated correlation coefficient, which is close to 0.96077, shows a great agreement between the predictive model and observed data given in Fig 5. This extremely high coefficient is a testament to the effectiveness of the ANN in representing the complex interdependencies between the wide range of input variables responsible for the generation of biohydrogen

$$MSE = \frac{1}{n} \sum_{i=1}^n (Y_{actual} - Y_{predicted})^2$$

$$x_n = 0.8 \left(\frac{x_i - x_{min}}{x_{max} - x_{min}} \right) + 0.1$$

Equ: Mean Square Error and No. of hidden neurons

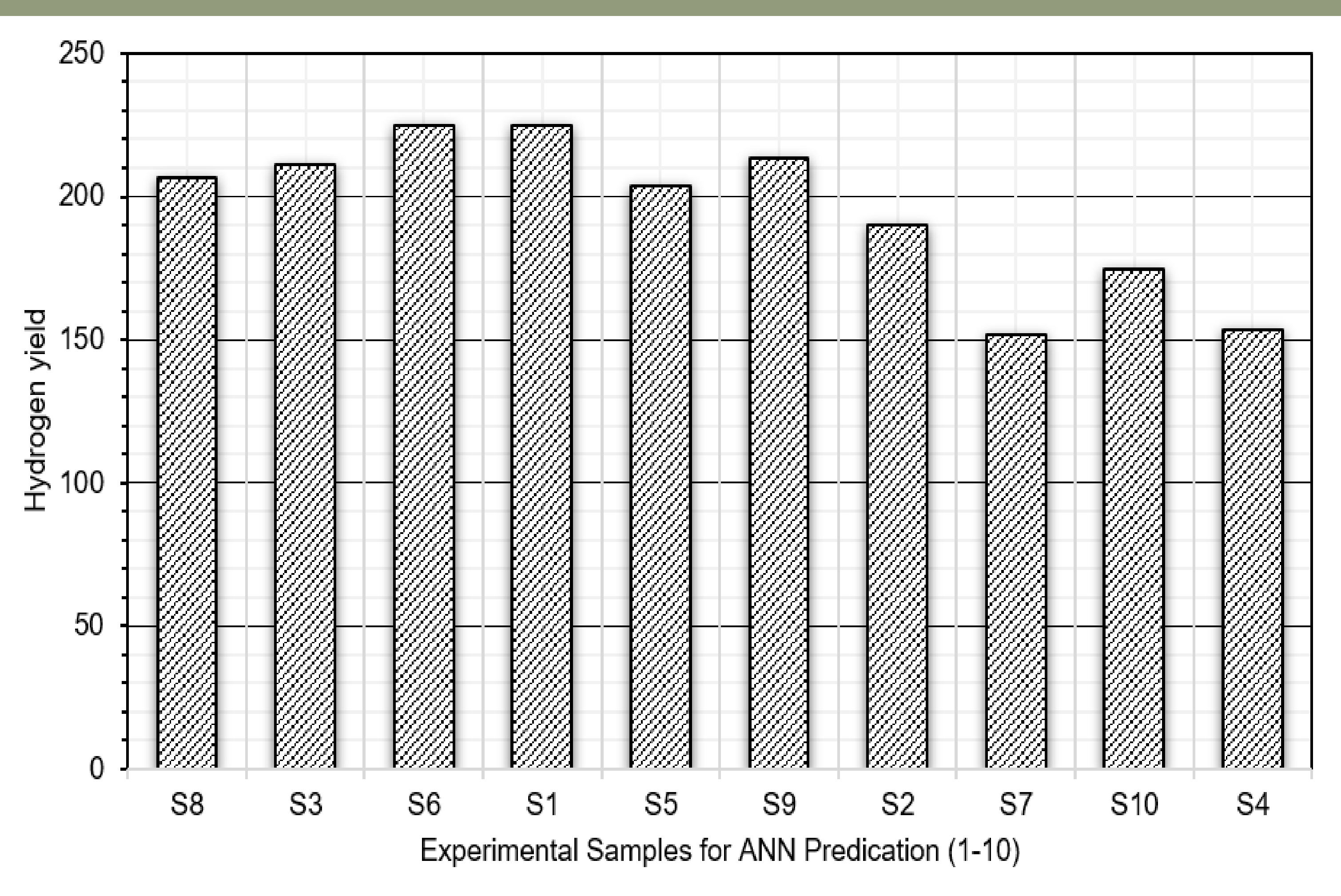


Figure: Predication of Hydrogen yield from 10 experimental samples

Conclusions

The expected results, after reviewing the literature and a proof-of-concept experiment, showed excellent outcomes, with a correlation coefficient (R²) of 96.07 % and a Mean Squared Error (MSE) of 0.02562. The H₂ yield is expected to be 224.74 mL H₂/g COD_{eq}. Bio-hydrogen production from the produced water through dark/photo fermentation is of great interest for sustainable waste valorization. It has the potential to shape the 'Green Hydrogen' economy in the industrial sector by providing an environmentally friendly, energy-efficient, and data-driven approach for its production

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