PREDICTION OF OPTIMAL ADSORPTION OF AQUEOUS PHENOL REMOVAL WITH OIL PALM EMPTY FRUIT BUNCH ACTIVATED CARBON USING ARTIFICIAL NEURAL NETWORK (ANN)

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Abstract
Adsorption process has an edge in wastewater treatment over other techniques due to low initial cost, sludge free, ease of operation and insensitivity to toxic substance. It involves both physical and chemical phenomena and hence susceptible to high percentage of errors due to human factor, variation in the quality as well as chemical/physical characteristics of raw materials used. In order to reduce this percentage error and obtain optimal treatment efficiency, an intelligent method of predicting optimal adsorption capacity based on Artificial Neural Network (ANN) was proposed. Production of Powdered Activation Carbon PAC from processed oil palm empty fruit bunches, EFB was used as adsorbent. Since production of PAC is affected by many parameters, such as CO_2 gas flow rate, activation time and activation temperature. Adsorption design was carried out using all these parameters, production results were analyzed. ANN was used to forecast optimal adsorption capacity for aqueous phenol removal. Such ANN based system will be a useful method to address most errors common in wastewater treatment cause by human factors.

Keywords: Artificial Neural Network, Adsorption, aqueous phenol, Powdered Activation Carbon, Wastewater treatment

1. Introduction

The main purpose of wastewater treatment is to maintain a good quality in the receiving waters by removing organic substances and nutrients (Sturm, 2012). This is essential to life of both human and animal communities.
This was the driving force for creation of environmental agencies such as the Global Environment Facility (GEF) to address global environmental issues, the Environmental Protection Agency (EPA) that helps in monitoring and ensure that the urban wastewater - effluent from houses and businesses are treated before it is discharge to rivers, estuaries or the sea in order to prevent pollution.
The wastewater treatment processes are very complex, it is a non-linear and characterized by many uncertainties such as the influent parameters, the structure and the coefficients of the model. Moreover, many wastewater treatment plants do not have measurement and control equipment. Therefore, there is a need in designing of intelligent method for better operation of the treatment plant.

Wastewater treatment is divided into three main processes.

1. Physical processes comprising screening or straining, sedimentation, flocculation and filtration.
2. Chemical treatment using adsorption, coagulation, ion exchange, precipitation.
3. Biological treatment processes with dispersed growth system (activated sludge, stabilization ponds); fixed film reactors (biological filters such as tricking filter)

Though wastewater treatment processes normally uses physical processes initially and later chemical processes like precipitation or adsorption. However, if it not sufficiently treated by these two processes, the three processes can be applied. Figure 1 show the complete wastewater treatment process chain.

2. Materials and Methods

The operating parameters for optimal ANN prediction include activation temperatures, activation times and CO_2 gas flow rate. These three parameters serve as input neurons

variables of the ANN at the input layer. Such parameters have the most influence on the determinant of the optimal condition for adsorption capacity of PAC produced from EFB. It has one output at the output layer which is the optimal adsorption capacity required for removal of phenol or pollutant in water treatment plant as shown in Figure 2.

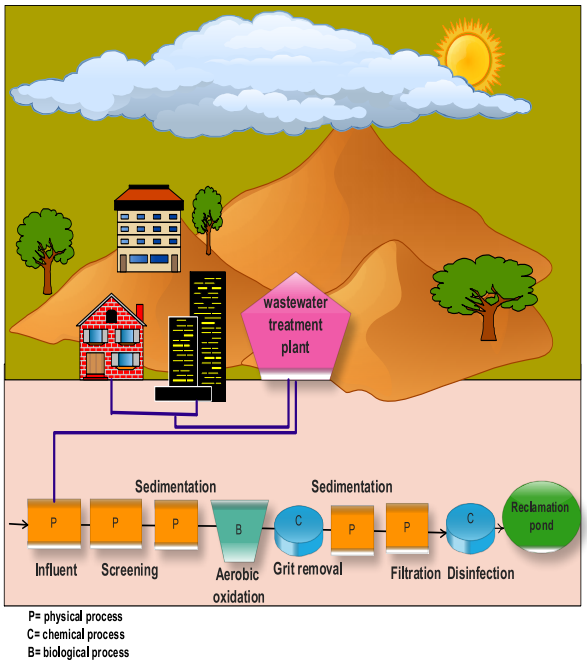

Figure 1: Wastewater treatment process chain

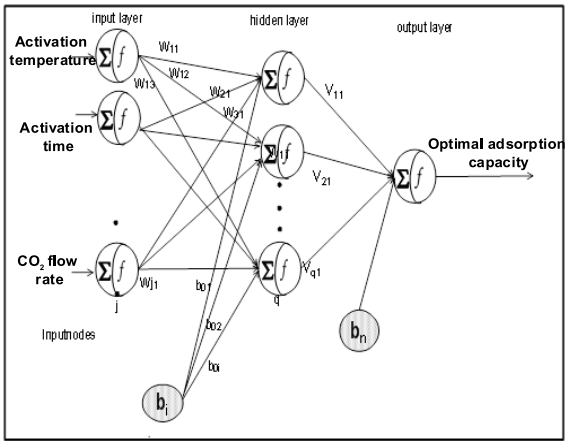

Figure 2: Multilayer feedforward NN for prediction of Optimal Adsorption capacity

The correlation between production of powdered activated carbons from oil palm EFB and their adsorptive capacities on phenol removal is nonlinear relationship. Therefore ANN based optimum adsorption capacity for removal of phenol involves 2 stages. The first stage involves determination of parameters affection adsorption capacity of PAC prepared from oil palm empty fruit bunches as an adsorbent. These parameters are then considered as input variables to the neural network for training to determine the adsorptive capacities on phenol removal.

3. Results and Discussion

The model is assumed for central point between average high and average low values for each parameter (activation temperature, activation time and CO_2 gas flow rate). 40% of the data sets were used for training subsequent 40% for test and 20% for validation. The theoretical, experimental and ANN based adsorption capacity of activated carbon produced for its optimum production is shown in Table 1.

From Table 1, it can be seen that the ANN results is closely resembles that of experimental. It is also observed from the Regression plot; which determine the strength and the relationship between the ANN proposed and experimental result. The data fit very well with yield of 0.9999 of 1.0000.This is an indicator that the ANN method predicted the data well as shown in Figure 3.

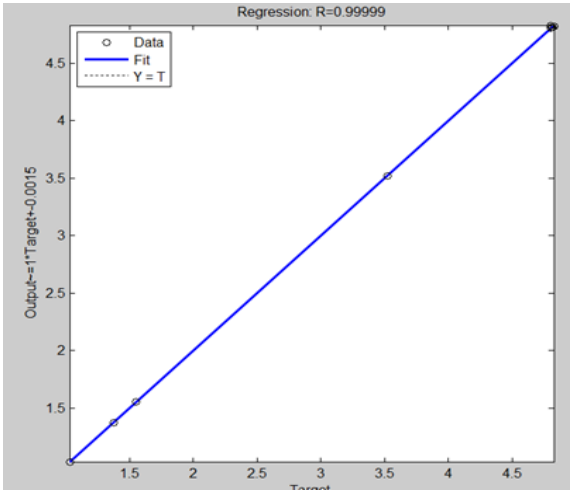

Figure 3: regression line of Experimental and ANN model for adsorption capacity

Table 2 further shows the statistical parameters, indicating that the ANN model produced a reliable estimation for optimal adsorption capacity based on input temperature, activation time and flow rate. The Coefficient of efficiency 1.000 indicated

that the model estimation is same as the observed value in experimental. Correlation coefficient shows the relationship between the NN prediction and the value recorded for the experimental results. Correlation coefficient of 1 indicated a perfect match of the model. Meanwhile the mean absolute error of 0.0008 implies that the error is highly insignificant which signifies that a very high accuracy is achieved by the model

4. Conclusions

The ANN predictive model for optimal adsorption of aqueous phenol removal with Oil Palm EFB Activated Carbon can make the operation of wastewater treatment plant more effective and accurate. The insignificant error produced by ANN model indicated effective utilization of resources. The correlation between experimental and ANN predicted model is 0.97 of 1.00. This High Correlation of coefficient indicates that the NN model is a perfect match.

References

Sturm M. (2012). New Challenges in Wastewater Treatment in Germany, Institute for Technology and Resources, Management in the Tropics and Subtropics Cologne University of Applied Sciences, Betzdorferstrasse 2, 50679 Cologne, Germany, http://jujubandung.wordpress.com/2012/06/05/new-challenges-in-wastewater-treatment-in-germany-2/

Table 1 Theoretical, experimental and ANN based results of adsorption capacity of activated carbon produced for its optimum production.

No of runs	Temperature (°C)	Activation time (min)	CO_2 gas flow rate (L/min)	K_t Theory	K_t Experimental	K_t ANN based
1	600	45	0.25	0.9300	1.0280	1.0283
2	600	15	0.10	1.2700	1.3710	1.3715
3	900	45	0.10	4.7300	4.826	4.8224
4	900	15	0.10	4.9000	4.8040	4.8231
5	900	15	0.25	4.7100	4.8040	4.8040
6	750	30	0.175	4.8100	4.8130	4.8099
7	600	45	0.10	1.4700	1.3720	1.3694
8	900	45	0.25	3.6200	3.5190	3.5189
9	600	15	0.25	1.6500	1.5520	1.5522
10	750	30	0.175	4.8100	4.8100	4.8099

Table 2: The best result obtained from ANN

Adsorption capacity	Statistical Parameters					
Adsorption capacity	Coeff. of efficiency	Corr Coeff.	RMSE	Mean Absolute error	MSE	NMSE
	1.0000	1.0000	0.0063	0.0008	0.00003	0.00001