Adsorption of UV$_{254}$ in Kerian River water onto Zeliac^{TM}: Analysis using linear and non-linear forms of isotherm models

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Abstract

The composite media, Zeliac^{TM} was developed with the initial aim to provide low cost adsorbent with promising adsorption capacity. This study was conducted to investigate the removal of UV absorbance at 254 nm (UV$_{254}$) in Kerian river water using Zeliac^{TM} as the media. Batch experiments study was carried out to determine the optimum removal of UV$_{254}$ by Zeliac^{TM}. The experimental data were fitted to Langmuir and Freundlich isotherms to investigate the adsorption mechanism. The results from batch study exhibit that Zeliac^{TM} is capable to remove 74.4% UV$_{254}$ at the dosage of 7g/100 ml. Linear isotherm analysis suggests that the best fitting linear line is Freundlich isotherm with R^2 values of 0.9294 indicating multilayer adsorption. Similarly, non-linear regression analysis reveals that the adsorption of UV$_{254}$ by Zeliac^{TM} is attributed by physisorption. The non-linear Freundlich isotherm gives a better fit to the adsorption of UV$_{254}$ than Langmuir isotherm with R^2 values of 0.9488. The results are supported with low values of X^2, ARE, HYBRID and MPSED from the error function analysis. Additionally, it is noted that the linear analysis overestimates the constant parameters' values for Freundlich isotherm, which cause larger errors as estimated by the error function analysis. Hence, non-linear analysis is more appropriate in explaining the batch experiment data.

Keywords: Aromatic compounds, Natural organic matter, equilibrium isotherm, composite adsorbent, error analysis

1. Introduction

Activated carbon has been acknowledged as the most effective porous media used to remove different types of contaminants. As a consequence, the price of activated carbon keeps increasing because of high demand. Therefore, several studies (Lafi *et al.*, 2014; Krishni *et al.*, 2014; Chan *et al.*, 2012; Wu *et al.*, 2011) have been conducted to search or develop new media that are comparable to activated carbon. In the meantime, the composite of activated carbon and zeolite shows a promising potential as alternative adsorbents (Foo and

Hameed, 2011). Basically, zeolite has a hydrophilic surface with cationic exchange ability; enables the adsorption of metallic ions and catalyst (Moussavi *et al.*, 2011; Ono and Yashima, 2000). In contrast, activated carbon has hydrophobic surface with nanometer pore size; suitable for adsorbing organic substances (Okolo *et al.*, 2000). In the past few years, a great interest is given in developing composite adsorbents either to increase the adsorption properties or create low-cost adsorbents. The characteristics, development and application of activated carbon/ zeolite composite materials are discussed by Foo and Hameed (2011).

Halim *et al.*, (2010) developed a new composite adsorbent namely Zeliac^{TM}. Zeliac^{TM} is a combination of an excellent adsorbent such as activated carbon, zeolite and low-cost adsorbents such as rice husk ash and limestone. This media produced with the target to treat high COD and NH$_3$-N concentration in landfill leachate. The results of the study show that Zeliac^{TM} performance in NH$_3$-N removal is better than activated carbon and zeolite and as good as activated carbon in term of COD removal (Halim *et al.*, 2010). Ammonia-N and COD are the examples of refractory organic matter which are difficult to be removed using the biological treatment process. Since the composite adsorbent has shown great performance in removing recalcitrant pollutants such as COD and NH$_3$-N, it is worth to examine this adsorbent in removing natural organic matter (NOM) component as NOM is known as resistant to biodegradation and conventional treatment processes in water treatment plant.

NOM consists of a complex mixture of inorganic and organic compounds with a wide range of molecular weight and variety functional groups (e.g. carboxylic acid, hydroxyl, phenolic and carbonyl group) (Johnson *et al.*, 2016). Humic substances which comprise of humic acid (HA), fulvic acid (FA) and humic are reported to be the major fraction (50 – 90% of DOC) of NOM in natural water depending on the location and seasons (Drikas *et al.*, 2011). Both HA and FA are negatively charged because of the presence of functional groups such as carboxylic acid

(COOH-), methoxyl carbonyls (C=O) and phenolic (OH-) (Zularisam *et al.*, 2006). In humic substances, fulvic acid was found hard to be removed by the conventional treatment system such as coagulation because FA is soluble at any pH and has low molecular weight (Abate *et al.,* 2006; Zularisam *et. al.,* 2006; Johnson *et al.,* 2016). Meanwhile, HA were less soluble and precipitate at low pH because of carboxyl group's protonated. Precipitation process causes the humic acid fractions to be removed from the system. The amount of NOM cannot be directly determined. Therefore, DOC or UV$_{254}$ are the parameters used as NOM surrogate. This study aims to investigate the capability of Zeliac^{TM} as UV$_{254}$ adsorbent by determining the adsorption isotherms.

In general, adsorption is a process that removes the adsorbate (soluble chemical) from a fluid or gas through a contact with the porous media surface (Itodo and Itodo, 2010). The understanding of adsorbate and adsorbent interaction is very important to optimize the design for water treatment application. The adsorbate is attached onto the adsorbent via physical or chemical bonds (Krishni *et al.*, 2014), which are known as the main removal mechanisms. The relationship between adsorbate and adsorbent in adsorption system can be determined by the equilibrium isotherm model. Langmuir and Freundlich isotherms are the most common models applied to describe the adsorption mechanism and surface individualities of the porous media. The linear regression analysis with linear expression of isotherm model is used as a tool to decide the best isotherm model to the experimental data. However, in the past few years, the applicability of linearly transform isotherm model has been questioned which increases in the use of non-linearized isotherm model to investigate the adsorption system (Foo and Hameed, 2010). Consequently, the applications of linear and non-linear isotherm models were explored. At the same time, the applicability of the isotherm models is determined using error deviation functions such as the average relative error deviation (ARE), hybrid fractional error function (HYBRID) and Marquardst's percent standard error deviation (MPSED).

2. Methodology

Adsorbent

The Zeliac^{TM} was prepared according to the method described by Halim *et al.,* (2006). The parent materials of Zeliac^{TM} comprises of zeolite clinoptilolite (45.94%), limestone (15.31%), coconut shell activated carbon (4.38%) and rice husk carbon (4.38%). These materials were mechanically mixed together with ordinary portland cement (30%) which acts as a binder. Meanwhile 60% of water from the total weight was added to form a slurry. The mixture was transfered into a mold and left to dry for 24 hours followed by curing. After 3 days of curing, the media was air dried before being crushed and sieved into the particle size of 1.18–2.36 mm which used in the entire study. Prior to the batch experiment, the sieved Zeliac^{TM} was washed using ultra-pure water (UPW) and dried at 105 °C in the oven for 24 h to remove the moisture content.

Then, the media was stored in the airtight container before using it in the batch study. The chemical composition of Zeliac^{TM} was determined using X-Ray Fluorescence (XRF). The results indicated that Zeliac^{TM} mainly encompasses of 55.1% Silicon (Si), 29.8 % Calcium (Ca), 8.7% Aluminum (Al), 2.5% Iron oxide (Fe$_2$O$_3$).

Sampling and Analytical analysis

Kerian River water was used as the sample in batch experiment. The area is surrounded by oil palm plantations and located near to housing communities/ villages. This river provides potable water to the residents of this area. The samples for the experimental study were collected near the water intake of Lubok Buntar water treatment plant. The travel time from sampling site to USM laboratory was 30 minutes. Hence, the samples were preserved in an ice box before reaching the laboratory. Then, the samples were stored in a cold room at a temperature less than 4 °C (APHA, 2005) until used in the experiments. Parameters such as temperature, pH, DO, SPC, TDS and salinity were measured in-situ using YSI Professional Plus Multi-parameter instrument. The concentration of turbidity was measured by Turbidimeter (model 2100 Q) while DR6000 UV-Vis spectrophotometer was employed for color, UV$_{254}$ and DOC determinations. Samples water for these parameters (color, UV$_{254}$ and DOC) were pre-filtered with a 0.45 μm nylon syringe filter from Whatman as soon as the sample arrived in the laboratory. The concentrations of UV$_{254}$ and DOC were measured based on the US EPA method 415.3. The results were presented in cm^{-1} unit and mg l^{-1} respectively. The presence of total coliform and *E. coli* was detected using Colilert test kit from IDEXX Corporation on the same day of the sampling date. The most probable number (MPN) for both total coliform and *E. coli* was obtained after 24 hours of incubation at 35°C ± 5°C. Close reflux and colorimetric method (5220D) were used to determine the COD concentration. All glassware and apparatus used were cleaned with 5% nitric acid and deionized water. The characteristics of Kerian River water are presented in Table 1.

Adsorption isotherm and kinetic experiments

A batch of 100 ml raw water samples with known UV$_{254}$ concentration was prepared in 250 ml conical flask. Then, different mass of Zeliac^{TM} (1.18 -2.36 mm) ranging from 1 to 10 g was added to the samples. The isotherm test was conducted by shaking all samples using CERTOMAT® SII Orbital bench top shaker at 200 rpm of shaking speed. The time of 105 minutes was set to allow a contact between samples and composite adsorbent. After that, the samples were passed through 0.45 μm filter paper before measuring the target compounds concentration. The experimental adsorption capacity (q_e) were determined using the equation below (Eqn.(1)).

$$q_e = (C_o - C_e) \frac{V}{m} \tag{1}$$

Where C_o represents the initial concentration and C_e denoted as the concentration at equilibrium. V is the volume of the samples in liter (l), and m is the weight of the dry adsorbent (g) employed in the experiment.

3.   Results and discussions

Table 1 summarizes the quality of Kerian River water, including NOM. The amount of NOM was estimated using two parameters; dissolved organic carbon (DOC) and UV_{254} absorbance. The average values of DOC and UV_{254} in the water were 3.8±0.84 mg l^{-1} and 0.12±0.06 cm^{-1}, respectively. Basically, the unit cm^{-1} represents the value of specific UV light absorb in proportion to UV absorbing organic concentration in the sample per unit length of the cuvette used (cm^{-1} or m^{-1}) as sescribed in the Standard Method 5910. Another surrogate parameter used to monitor the NOM was the Specific UV absorbance (SUVA). SUVA is a ratio of UV_{254} to DOC which gives information on the hydrophobicity of NOM in the water. The results of SUVA (3.00 ± 1.1 l mg^{-1} M^{-1}) implies that Kerian river water contained both hydrophilic and hydrophobic NOM fractions (Wang *et al.,* 2013).

Previous studies have reported that humic substance fractions (HA and FA) in NOM is the main components responsible for the formation of hazardous disinfectant by-products (DBPs) in drinking water system (Johnson *et al.*, 2016). The existence of humic substances such as HA and FA in natural water can be detected through the colour of the water. In this study, PtCo unit was applied for colour measurement. The PtCo unit was used for colour measurement based on visual comparison of sample with Platinum-Cobalt colour standards. According to Standard Method 2120 B, 1 unit colour is represented by 1 mg l^{-1} platinum in the form of choroplatinate ion. Typically, light yellow, yellow and brown are the colours attributed by FA while dark brown, grey or black are the colours produced by HA presence. During the 6 months of monitoring, yellow or light yellow river water was frequently observed, suggesting that FA is a dominant fraction in Kerian River water.

Table 1. The summary of Kerian River water characteristics monitored for 6 months

TEST PARAMETER	Unit	Min	Max	Average ± Std Dev
Temperature	°C	25.5	29.3	26.8± 1.1
DO	mg l^{-1}	2.1	4.8	2.7± 1.1
Specific Conductivity (SPC)	µS cm^{-1}	37.3	74.4	50.7± 15.1
Total dissolved solid (TDS)	mg l^{-1}	24.0	48.3	31.0± 9.3
Salinity	ppt	0.02	0.03	0.02± 0.005
pH		6.0	6.8	6.3± 0.23
Turbidity	mg l^{-1}	21.7	160.0	121.7± 48.6
Colour (True Colour)	PtCo	4.0	47.0	22.1± 13.5
NH_3-N	mg l^{-1}	0.2	3.0	1.1± 0.8
COD	mg l^{-1}	4.0	21.0	12.1± 4.2
Total Coliform	MPN/100ml	2419.6	9208	5813.8± 4800.1
E.Coli	MPN/100ml	209.8	980.4	553.9± 338.23
DOC	mg l^{-1}	2.7	5.3	3.8± 0.84
UV_{254}	cm^{-1}	0.03	0.23	0.12± 0.06
SUVA (UV_{254}/DOC)*100	L mg^{-1} M^{-1}	1.15	4.30	3.00± 1.1

Besides colour, other parameters such as pH and COD were related to the presence of NOM in the water (Zhang and Liu, 2010). Hence, further analysis was conducted using linear regression analysis to find the correlation of NOM with parameters listed in Table 1.The results are shown in Figure 1. UV_{254} was used as the surrogate to NOM. This parameter (UV_{254}) was selected as the studied parameter because of its sensitivity to aromatic component and indicator for HA and FA fractions (Drikas *et al.,* 2011; Zhang and Liu, 2010).

Among all parameters, high correlation was observed between UV_{254} and colour with R^2 value of 0.9545. Fairly good result was acquired in UV_{254}-COD relationship where the R^2 value of the linear regression analysis was 0.7294. The correlations of UV_{254} with other parameters were weak, therefore, the graphs are not presented in this paper. In addition, the correlation between UV_{254} and DOC

was also inspected. According to the result, a high R^2 value of 0.9845 was obtained from linear regression analysis of UV_{254}-DOC. The relationship between DOC-COD was also inspected. A comparable R^2 value to UV_{254}-COD was achieved as shown in Figure 1. Good correlations between UV_{254}-colour and UV_{254}-DOC implies that the concentration of colour and DOC changed proportionally with the changes of UV_{254} concentration. Since strong correlation was obtained between UV_{254} and DOC, only one parameter was selected as an indicator in the batch experiment study. UV_{254} was selected because the measurement method is simpler and easier compared to DOC. In addition, no hazardous chemical was needed, produced or released to the environment. Hence, this parameter was used in the isotherm analysis to evaluate the batch experiment data and investigate the reaction involved in the adsorption process.
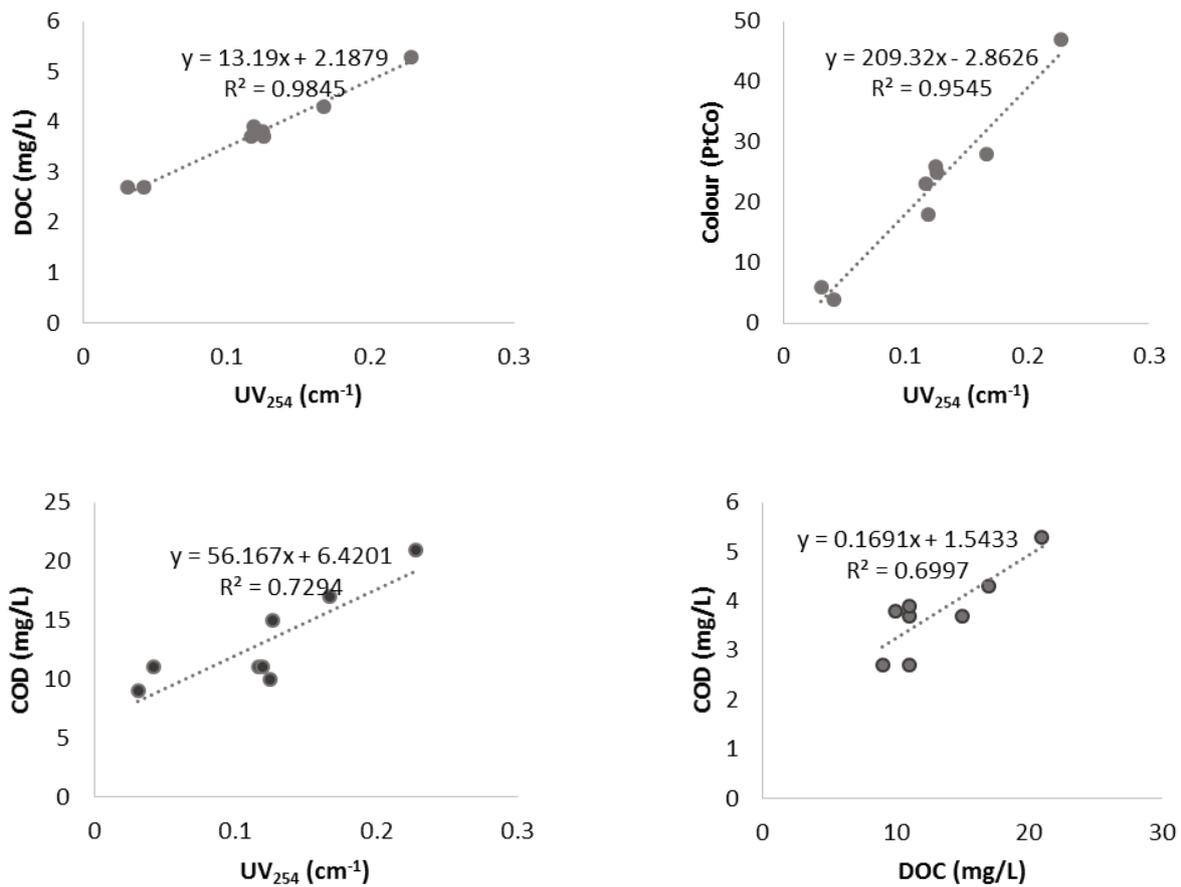
Figure 1. The correlation of UV$_{254}$ with DOC, COD, and colour as well as relationship between DOC and COD
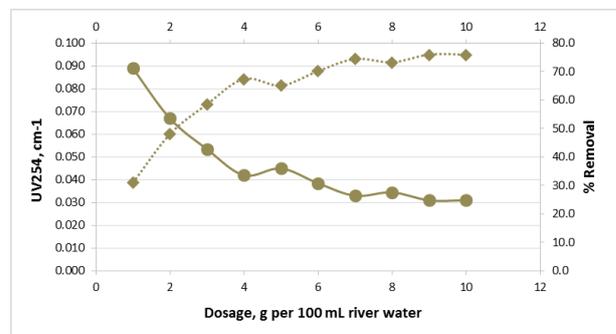
Effect of dosage

The batch experimental data were used to determine the removal percentage of UV$_{254}$ by Zeliac™. The calculation of percentage removal was computed by using Eqn. (2).

$$\text{Percentage removal} = \frac{(C_o - C_e)}{C_o} \times 100 \qquad (2)$$

Where C_o and C_e are initial and equilibrium concentrations of the target pollutant typically denoted in a unit of mg l^{-1}. However, UV$_{254}$ absorbance was used as removal parameter, therefore, the concentration unit of C_o and C_e was changed into cm^{-1} to represent UV$_{254}$.

The initial concentration of UV$_{254}$ in the samples was 0.118 cm^{-1}. Fig. 2 shows the percentage removal and reduction of UV$_{254}$ in the water samples with increasing of Zeliac™ dosage. As shown in the graph, the increasing of Zeliac™ dosage increased the removals of UV$_{254}$. This is because the number of exchangeable/absorbable sites for adsorbate increased (Moussavi *et al.*, 2011), inevitably percentage removal of UV$_{254}$ escalated. The optimum removal of UV$_{254}$ by Zeliac™ was estimated at the dosage of 7 g with percentage removal of 74.4%. Further addition of Zeliac™ after this point, did not give a significant change in the UV$_{254}$ uptake as shown in Fig.2. The results indicated that Zeliac™ has reached the adsorption equilibrium, where the maximum capacity of the adsorbent to adsorb adsorbate was reached.

Figure 2. Effect of Zeliac dosage to the adsorption of UV$_{254}$ in Kerian River water

Table 2 lists the removal efficiency of Zeliac™ and other adsorbents to remove humic substance. It revealed that Zeliac™ recorded the highest removal efficiency of UV$_{254}$ compared to GAC (34.9%) and fly ash (23.3%) (Wei *et al.*, 2011; Moussavi *et al.*, 2011; Wei *et al.*, 2008). However, the performance of Zeliac™ is slightly lower than Zeolite. Considering the types of water sample used, lower efficiency of Zeliac™ may be caused by attachment of other impurities in river water onto Zeliac™ during the adsorption process which limits the available sites for UV$_{254}$ attachment.

Table 2. Removal efficiency of NOM using different adsorbent

Adsorbent	Types of Water samples	Target parameter	Removal efficiency/ Uptake Capacity	References
Fly Ash	Secondary effluent of Wastewater Treatment Plant	UV_{254}	25.9 %	Wei *et al.,* 2011
Granular activated carbon (GAC)	Secondary effluent of Wastewater Treatment Plant	DOC UV_{254}	DOC - 38.7% $UV_{254} - 34.9\%$	Wei *et al.,* 2008
Zeolite	Synthetic water	Humic acid	76.5%	Moussavi *et al.,* 2011
Zeliac^{TM}	River Water	UV_{254}	74.4%	This study

Adsorption isotherms

Langmuir and Freundlich isotherm models were selected to evaluate the experimental outcomes. The non-linear and linear equations of Langmuir and Freundlich isotherms are shown in Table 3. In Langmuir model, two assumptions were made; 1) adsorbent has a fixed number of sites and 2) binding at most one molecule per site (Foo and Hameed, 2010). Parameter Q and b are Langmuir constants which represent the maximum monolayer coverage and adsorption energy, obtained from the slope and intercept of the linear plot. Meanwhile, C_e (cm^{-1}) indicates the final concentration, whereas q_e presents the adsorbate uptake by unit mass of adsorbent.

Table 3. Linear and non-linear expression of Langmuir and Freundlich isotherm models

Isotherm	Non-Linear form	Linear form	Plot
Langmuir	$q_e = \dfrac{QbC_e}{(1+bC_e)}$	$\dfrac{1}{q_e} = \left(\dfrac{1}{Qb}\right)\dfrac{1}{C_e} + \dfrac{1}{Q}$	$\dfrac{1}{q_e}$ vs $\dfrac{1}{C_e}$
Freundlich	$q_e = K_F C_e^{\frac{1}{n}}$	$\log q_e = \log K_F + \dfrac{1}{n}\log C_e$	$\log q_e$ vs $\log C_e$

Meanwhile, Freundlich model represents multilayer adsorption of sorbate onto the heterogeneous surface of the adsorbent. K_F and $1/n$ are two constant parameters determined in Freundlich model. K_F corresponds to the adsorption capacity that reported in (mg/g)(l/mg)$^{1/n}$ unit, while $1/n$ (unitless) signify adsorption intensity. This isotherm model applicability is determined by plotting a linear graph log q_e versus logC_e. Similar to the Langmuir isotherm model, the constant values of K_F and $1/n$ are obtained from the intercept and slope of the graph.

Linear plot of $1/q_e$ against $1/C_e$ produces a slope and intercept of 1/Qb and 1/Q, respectively. Meanwhile, the values of Q and b of non-linear regression were determined using *solver* add-in, Microsoft Excel 2010. The values of calculated Q and b are listed in Table 4. As stated by Wu *et al.,* (2011), negative values of Q and b signify that the surface of Zeliac^{TM} has heterogeneous coverage instead of monolayer coverage. Interestingly, analysis of the experimental data using non-linear equation of Langmuir isotherm gave an opposite explanation, where positive values of both Q and b were obtained. Since UV_{254} is expressed in cm^{-1} unit, the values of q_e and Q were represented by cm^{-1} lg^{-1} instead of mg g^{-1}. The unit of cm^{-1} represents a light intensity measurement at specific

wavelength. Hence, unit of cm^{-1} lg^{-1} depicted the UV_{254} absorption in volume of sample per weight of Zeliac^{TM} with respect to path length of the cuvette used (cm^{-1}).

A contradict result was obtained. Therefore, R^2 values between linear and non-linear analysis were compared. R^2 was used to measure the strength of the model by determining the closeness of R^2 value to the unity. The value of R^2 nearest to 1 denoted that the model has better suitability (Ayoob and Gupta, 2008). In this study, the R^2 values of non-linear analysis exhibit higher R^2 value than linear analysis as shown in Table 4 implying non-linear analysis of Langmuir isotherm fits better to the experimental data. However, error function analysis such as ARE, HYBRID, and MPSD insinuated that linear form was better to represent the adsorption. As a result, the graph of q_e versus C_e was plotted (Fig. 3) and confirmed that a non-linear form of Langmuir isotherm fits better with the experimental data.

The applicability of linear and non-linear Freundlich isotherm to the adsorption of UV_{254} by Zeliac^{TM} was also determined. The constant parameters (K_F and $1/n$) of Freundlich isotherm estimated by linear and non-linear expression were presented in Table 4. The values of K_F for linear and non-linear Freundlich isotherm were 0.3622 and 0.0672, respectively. It is noted that there were large difference of K_F obtained between linear and non-linear analysis. In the correlation coefficient analysis, both linear and non-linear analyses suggest a good correlation where the R^2 values recorded are more than 0.9. Despite that, all error function analysis tested were not in agreement with linear Freundlich isotherm where high values of error were obtained (Table 4). This result indicates that the linear equation is not suitable for fitting the batch adsorption data. Moreover, a graph of q_e versus C_e in Fig. 3 clearly shows that the graph for linear Freundlich isotherm was deviated from the experimental data. Besides, the non-linear Freundlich curve was perfectly aligned with the experimental data from low to high concentration of UV_{254}.

Overall, the R^2 values (>0.9) exhibit that linear and non-linear form of Langmuir and Freundlich isotherms were appropriate to describe the adhesion of UV_{254} onto Zeliac^{TM}. However, it is observed that the linearization of non-linear isotherm expression causes inherent bias which lead to the wrong interpretation (Ayoob and Gupta, 2008).
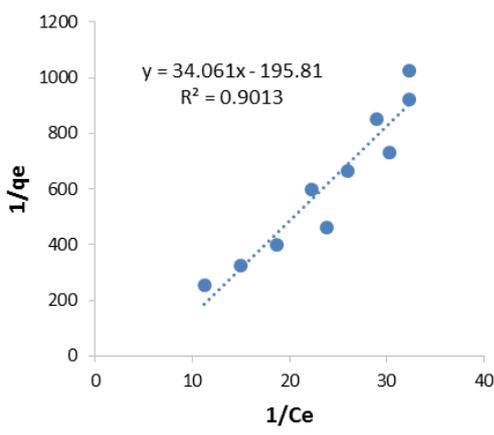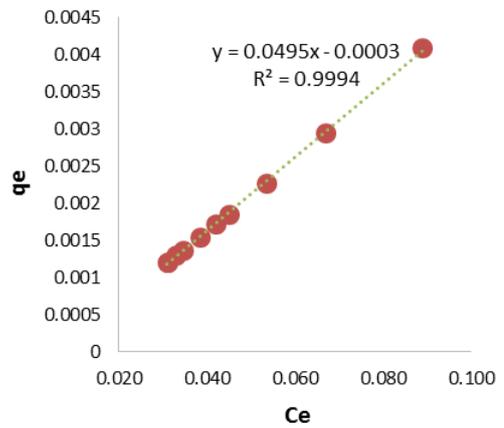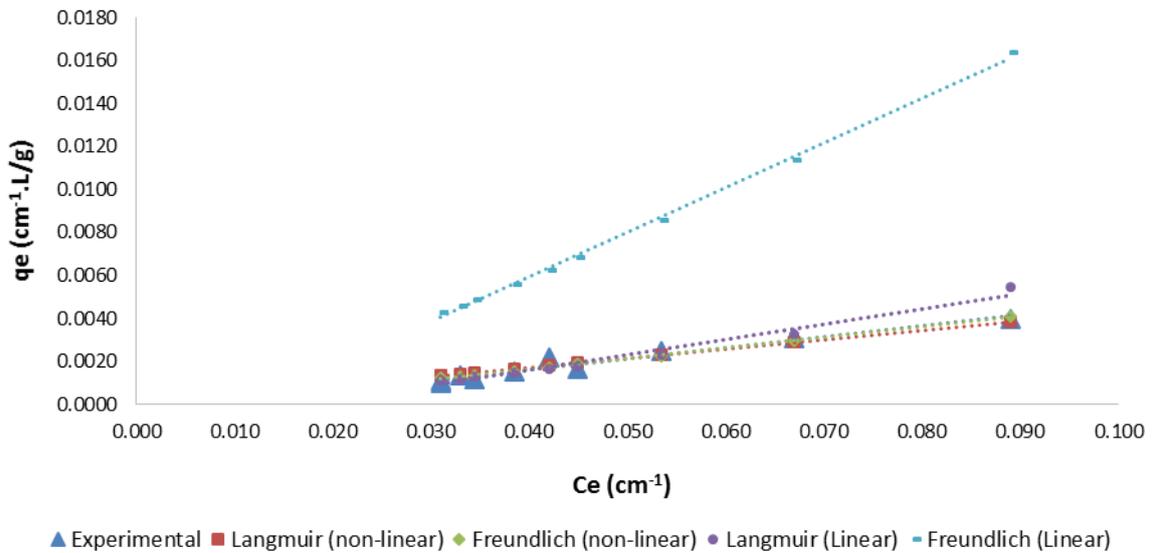
(a) Langmuir: Linear plot
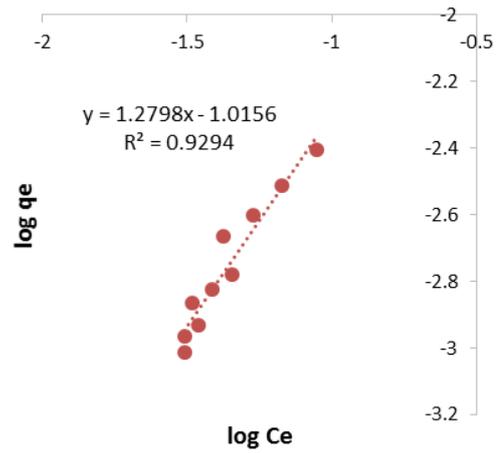
(b) Freundlich: Linear plot
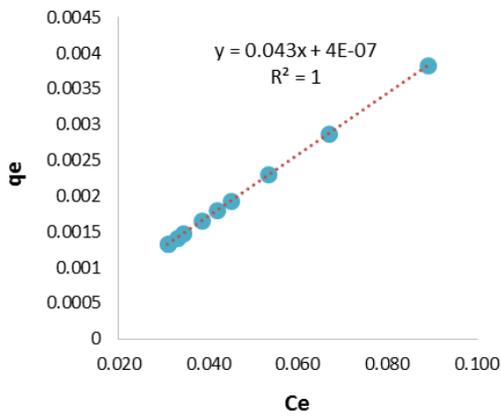
(c) Langmuir: Non-Linear plot

(d) Freundlich: Non-linear plot

(e) Experiment data and predicted value of linear and non-linear isotherm

Figure 3. Plot of experimental data and the predicted equilibrium curve for the linear and non-linear regression of Langmuir and Freundlich isotherm models

As exhibited in Fig.3, the adsorption capacity of linearized Freundlich isotherm was overpredicted which caused the fitting distorted far from the experimental data and obtained high error value (Table 4). According to Subramanyam and Das (2014), the conversion of non-linear to linear equation misrepresents the experimental error, thus restricted the validation determined by error function and statistical tools. In order to prevent the errors, non-linear regression method was applied. The R^2 of non-linear Freundlich isotherm was closer to the unity with the value of 0.9488 demonstrating that the adsorption of UV_{254} on $Zeliac^{TM}$ surface was the physical process. Furthermore, the conclusion was supported by the error function analysis where X^2, ARE, HYBRID, and MPSD show the lowest error values for non-linear Freundlich isotherm.

In Langmuir isotherm case, the linearized equation produced negative values to both constant parameters (Q and b). The constant b explained adsorption in term of the ratio of the adsorption and desorption rate, which directly associated with the binding energy (Ayoob and Gupta, 2008). Thus, the negative value of b implied no chemical

bonding in the adsorption of UV_{254} onto $Zeliac^{TM}$. In contrary, the non-linear equation demonstrated positive chemisorption where high values of Q were obtained. As a result, error analysis functions were used to verify the applicability of linear and non-linear Langmuir isotherm in describing the adsorption of UV_{254} on $Zeliac^{TM}$. The results of this analysis support the linear regression analysis which suggests that the $Zeliac^{TM}$ surface is heterogeneous instead of monolayer. However, when a graph of q_e versus C_e for each equation was plotted, the non-linear graph illustrated better fitness compared to the linear equation which has an opposite conclusion from the error analysis. Since the results of R^2, error analysis and plotted graphs were not synchronized, it is harder to make a conclusion whether the chemical adsorption are involved in this adsorption system. Based on the above reasons, Freundlich isotherm model obviously more suited to describe the adsorption of UV_{254} onto $Zeliac^{TM}$. Hence, it can be concluded that the relationship of UV_{254} and $Zeliac^{TM}$ in this adsorption system was attributed by physical adsorption.

Table 4. Isotherm models and error functions analysis.

Isotherm		Error Function				
Langmuir-2		R^2	X^2	ARE	HYBRID	MPSD
Linear		0.9013	0.0008	12.2449	0.6319	9.3924
Q	-0.0050					
b	-5.8370					
Non-Linear		0.9294	0.0004	15.0346	18.7932	29.2840
Q	12.7110					
b	0.0034					
Freundlich						
Linear		0.9294	0.1508	277.9630	347.4538	982.7477
K_F	0.3622					
1/n	1.2798					
Non-Linear		0.9488	0.0003	10.9293	13.6616	11.4786
K_F	0.0672					
1/n	1.1564					

4. Conclusion

The potential of Zeliac in removing UV_{254} was studied and the results showed that $Zeliac^{TM}$ was able to remove 74.4% of UV_{254} at the dosage of 7 g in 100 ml sample; indicated the applicability of $Zeliac^{TM}$ for removing UV_{254} in the river water. The sorption behavior of UV_{254} by $Zeliac^{TM}$ was examined using Langmuir and Freundlich isotherm models. By comparing the results obtained from R^2, error function analysis and plotted graph (q_e versus C_e), it was strongly suggested that the adhesion of UV_{254} occured at a multi-layer surface. The non-linear equation of both Langmuir and Freundlich isotherms showed better fit with the experimental data compared to a linear equation. These results implied that non-linear regression method provided better analysis for the adsorption process. The batch study data were well described by the non-linear regression of Freundlich isotherm. Thus, it can be concluded that the main mechanism for the adsorption of UV_{254} on $Zeliac^{TM}$ is physical in nature.

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