Potential Silt as Adsorbent in Removing Methylene Blue from Aqueous Solution

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Abstract

There is little study about silt that was used as adsorbents for the removal of methylene blue from wastewaters. Therefore, the potential of silt as adsorbent to remove or adsorb the methylene blue dye from waste water were studied. As the water pollution problems have been increasing from year to year and dye waste is one of the major contribute to the water pollution, the common chemical and physical treatment such as reverse osmosis and membrane filtration are not economically feasible. Therefore, the parameters such as effect of adsorbent dosage, effect of initial concentration of methylene blue, effect of pH, and effect of contact time was conducted to study the use of adsorbent silt.The adsorption was study and observed by using Equiptronics single beam u.v. visible spectrophotometer. The result shows for the effect on adsorbent dosage, effect on initial concentration, effect on pH, and effect on contact time that the adsorption of methylene blue increasing as the adsorbent dosage is decreasing, the initial concentration increasing, at the optimum pH which is 3 and as the contact time increasing respectively. Therefore, silt shows the positive result towards all experiment that has been conducted and have high potential to be an adsorbent.

Keywords: low cost, adsorbent, methylene blue, dye

1. Introduction

Dye productions are widely being explored because of its highly demands especially for painting, textiles (Ouadjenia et al.), paper, and plastics (Carmen & Daniela, 2012). There are two types of dye which are natural dye, and synthetic dye. Natural dye means it is produce naturally without adding anything. For example, red-cabbage, and red-perilla (Furukawa et al., 2009). While example of synthetic dye is Methylene Blue, Malachite Green, and etc. For industrial uses, synthetic dye is being use instead of natural dye because it provided richer color throughout washing and exposure (Fatiha & Belkacem, 2016).

Textile industry plays an important role in the economic development but it has causes serious problems such as water pollution (Jamwal et al., 2017) (Omer et al., 2017)to environment when it being disposed into wastewater (Fatiha & Belkacem, 2016). Usually process for dyeing fabric they used reactive dye (Koyuncu, 2002) widely in industries and this have causes harmful to aquatic living. The term of "reactive dye" means, during the process of chemical reaction, it attaches themselves to their substrates. This form a covalent bond between the molecules of dye and the fiber. Hence, the dye has been part of the fibre and it's harder to be removing. It also causes harmful (Varghese et al., 2017) to aquatic living because during the process, they use toxic chemicals and discharged untreated effluent. This effluent is harmful towards environment because it drastically reduces the oxygen content due to presence of hydrosulfides that prevent light from passing through water body which disturb water ecosystem. Therefore, there are existing solutions which are classified into chemical, physical and biological methods. Physical method, its included adsorption, exchange of ion, and coagulation. While chemical method, they used ozonisations, Fenton reagent, and photocatalytic process. Lastly, for biological method (Umoren et al., 2013) it included aerobic degradation, anaerobic degradation and biosorption.

The effective method to remove dye from the industrial waste water effluent is using adsorption method which used activated carbon for the adsorbent. However, the activated carbon is really expensive (Crini, 2006). Hence, the alternative methods for adsorption are rising because the demand for low-cost (Islam et al., 2017) treatment is increasing (Gupta, 2009). Therefore, the idea is to come out with an adsorbent that efficient and easy to find which is silt. Silt that being used in this experiment is abundant silt that was taken from construction pond. Therefore, it will be wasted if not be used and will become damping site.

Silt may occur as soil which often mixed with sand or clay. Silt has floury and slippery feel when it's dry and wet respectively. Silt also cannot be seen with bare eyes. Silt has the characteristic that need to be further study that can make it as a good adsorbent. Size range of silt which is 0.05-0.002 mm is between clay and sand where mineral origin is quartz and feldspar (Smalley, 1995).

There are many studies of the adsorptive property of clay and sand but not been thoroughly investigated for silt properties. Clay show high adsorption compared to sand because it has high specific area, mechanical and chemical stabilities and various of surface and structural properties (Liu & Zhang, 2007). Unfortunately, there are no studies of silt in detail, therefore the purpose of this study is to determine the possibility of removing methylene blue using silt. Therefore, literature on cationic dye adsorption by silt to anionic dye adsorption onto natural silt has been studies. As to identify the possibility of silt in removing the dye color, effect on dye concentration, pH, adsorbent dose and contact time have been evaluated in this study (Mohan et al., 2002).

2. Methodology

2.1 Preparation of Adsorbent

The silt sample collected from construction pond was treated before using in the adsorption experiment. Firstly, a distilled water suspension of silt was dispersed for 4 hours and then cleaned several times with de-ionized water. The fine fraction of silt was collected by repeated dispersion, sedimentation techniques. Then, the solid sample, was dried in the oven at 95°C for 24-hour. The dried silt is then crush into powder form and sieved by using 125 micro meter sieve.

2.2 Preparation of methylene blue

Methylene blue solutions were prepared at 2ppm, 4ppm, 6ppm, 8ppm and 10ppm (desired concentration) of concentration. Therefore, stock methylene blue solutions were prepared which is 1000ppm from dissolving the methylene blue powder in distilled water (Guesmi et al., 2018) to prepare those desired concentration of solutions. Those different dye concentrations were dilute from 1000ppm stock solution.

2.3 Adsorption Studies

Adsorption studies were performed by the batch technique to obtain equilibrium data. The adsorption capacity of silt was determined by conduct experiment using 0.1g in each bottle samples which contain 40ml methylene blue (MB) and shake it for 4 hours at 25°C. The absorbance of residual concentration of methylene blue will occur during the shaking process. HCl and NaOH were used to adjust the pH of the methylene blue solution as per the requirement. Specific amount of adsorbent was shaken in 40mL aqueous solution of dye varying concentration at natural pH and constant temperature. At the end of the pre-determined interval, absorbent was removed by centrifugation at 10000 rpm. The value of amount of dye absorbed calculated using equation 1 (Omer et al., 2017) (Novais et al., 2018):

$$Amount\ adsorbed = \frac{(initial\ concentration) - (final\ concentration)}{mass\ adsorbent}\ x\ Volume$$

Equation 1

2.4 Effect of Dye Concentration

Initial Methylene Blue concentration of 2, 4, 6, 8, 10ppm were in conjuction with adsorbent dose (0.1g), contact time (240 minutes), 6-7 pH solution, agitation speed (300rpm), temperature 25°C

2.5 Effect of pH

Initial pH of methylene blue solution was adjusted to 3, 5, 7, 9, 11 for 10ppm of concentration, contact time was at 240 minutes, the dosage of adsorbent used was 0.1g, and agitation speed was at 300rpm at 25°C of temperature.

2.6 Effect of Adsorbent Dosage

Initial adsorbent dosage 0.1g ,0.2g ,0.3g ,0.4g ,0.5g, contact time 240 minutes, agitation speed 300rpm,25°C temperature at 10ppm of concentration (Fatiha & Belkacem, 2016).

3. Results and discussion

3.1 Effect of adsorbent dosage

The effect of adsorbent dosage in methylene blue is an important parameter to be studied. It is because it will determine the amount of methylene blue that will be adsorbing by the adsorbent which is silt. The amount of methylene blue that was adsorbed was evaluating using Ultraviolet Visible Spectrometer (Uv-Vis). The experiment that carried out was by contacting different amount of adsorbent silt from the range (0.1g-0.5g) with 40 ml of methylene blue dye solution. The shaken process was made at 300rpm for 4 hours at 25°C.

Fig 1 depicts the amount of adsorption versus adsorbent dose. The amount adsorption was decreased with increasing the adsorbent dose. A maximum of almost 100% adsorption of methylene blue was observed by 0.1g of silt. This is due to its maximum surface area of adsorption available. It can also know as instauration (Filipović-Kovačević et al., 2000) which means the larger the amount of adsorbent used, the larger the surface area will create, therefore the adsorption process take longer time for the adsorption.

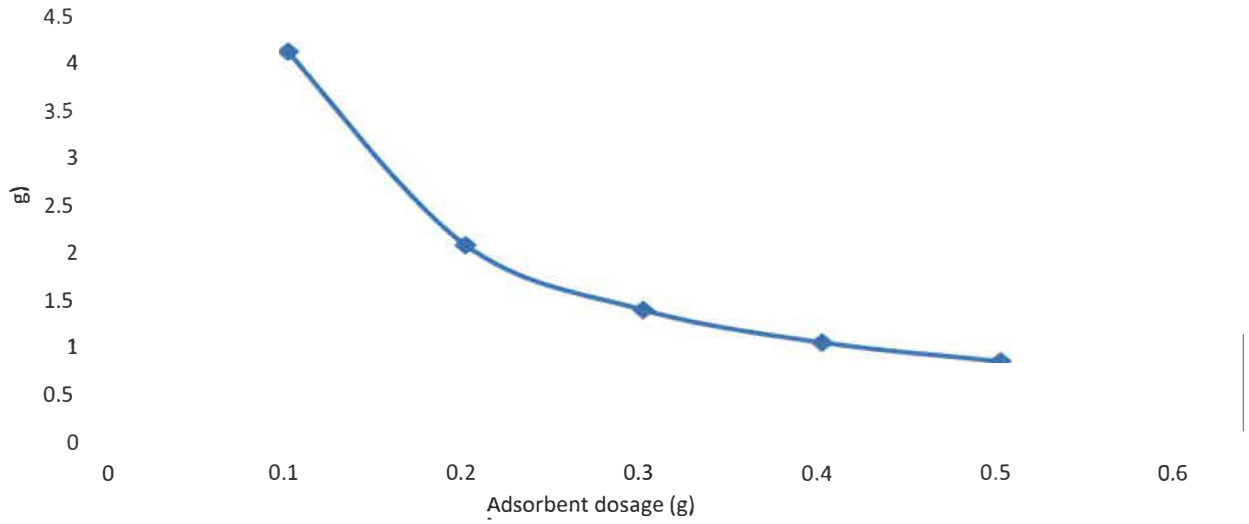

Fig 1: Effect of adsorbent dose on the amount of dye adsorbed per unit weight (Qe)

3.2 Effect of initial concentration of methylene blue

The effect of varying concentration of methylene blue on the adsorption is shown in Fig 2. The figure shows the graph of amount adsorption versus initial concentration. As expected, the result obtained, as increase the initial concentration will increase (Doğan et al., 2004) the adsorption. From data obtained a maximum amount of adsorption was at concentration of 10ppm. This is due to the driving force to overcome the resistance of methylene blue between aqueous solution and solid phase (Ouasif et al., 2013) occur. Therefore in order to increase the interaction between adsorbate and adsorbent, the concentration also need to be increase.

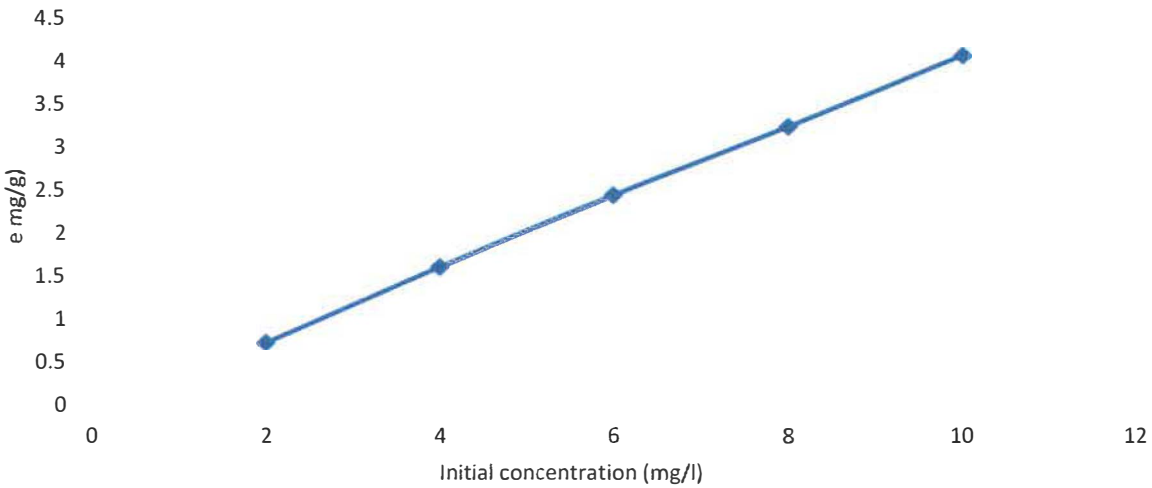

Fig 2: Effect of initial concentration of methylene blue on the amount of dye adsorbed per unit weight (Qe)

3.3 Effect of pH

From the previous research, it stated that the amount of methylene blue dye adsorbed per unit weight of adsorbent (Qe) increases when the value of pH increases. Methylene blue is a compound that having a bronze like luster so due to the electrostatic force of attraction, molecules of methylene blue is adsorbed on the surface of silt. Furthermore, the maximum methylene blue removal was observed at pH 11. When the dyes dissolved in water it gives a positively charged ions. So commonly, in acidic medium such as pH 3 and 5, the positively charged surface of adsorbent tends to oppose the adsorption of the cationic adsorbate that is silt. While vice versa occurs when pH of dye solution is at base medium which are at 9 and 11. It is because more -OH ions will release and on positive charge active sites, when pH is increase. According to research, when pH of dye solution is increased the surface acquires a negative charge, there by occurring in an increased adsorption of methylene due to an increase in the electrostatic attraction between negatively charged adsorbent and positively charged dye.

Unfortunately, the experiment conducted was inversely from the theory research. As illustrated in Fig 3, the maximum methylene blue removal was at pH 3 where value the value adsorption is 3.96396mg/g. After achieving the maximum value of adsorption at pH 3, the amount of methylene blue dye adsorb is continuously decreasing. In addition, at pH 11, the value adsorption is the lowest which is 2.12764mg/g. This is due to some error which are human error and equipment error. For human error, it must be because of the steps during conduct the experiment while for equipment error is due to the shaker used that exposed to disturbance.

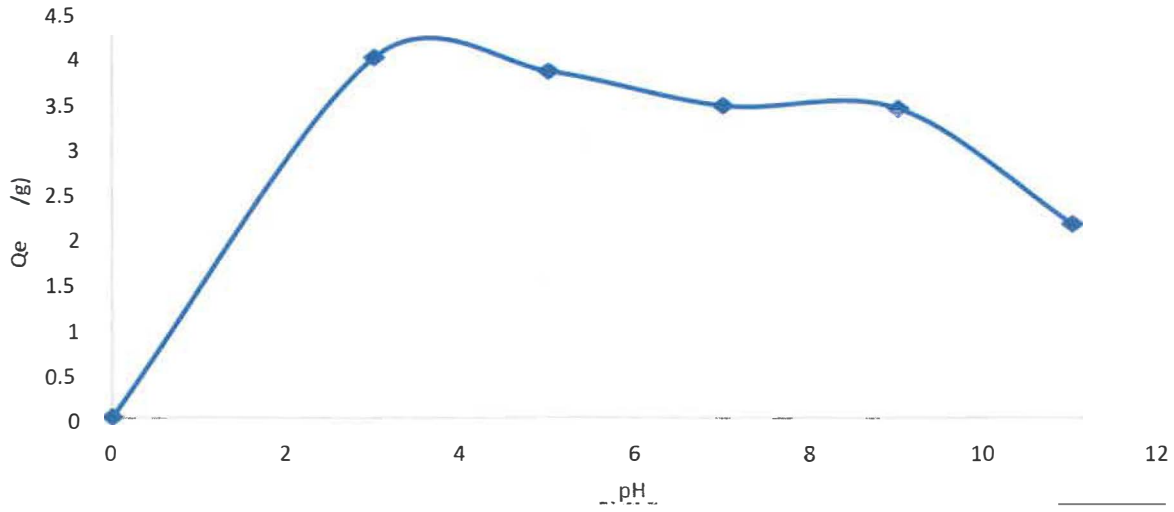

Fig 3: Effect of pH on the amount of dye adsorbed per unit weight (Qe)

3.4 Effect of contact time

In order to achieve the effect of contact time, initial concentration of methylene blue was kept constant at 10ppm with adsorbent dosage at 0.1g.Fig 4 depicts the results obtained and it was observed that the adsorption increase as the contact time increase until at one point where the adsorption is no change because it have achieved equilibrium. As for the effect of contact time, theoretically as the contact time increase the amount of adsorption also increase until at certain point where it will achieve equilibrium. This is because as the contact time is increases, the collision between particles of adsorbate and adsorbent was bigger. Unfortunately, from experiment conduct, at 20 minutes of the experiment the adsorption value is 3.52428mg/g and the value slightly decreased at 40 minutes of the experiment. Then, the value increased again at time 60 minutes which is 3.76348mg/g but it decreased again during 100 minutes