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COMPARATIVE STUDY FOR REMOVING REACTIVE ORANGE DYE BY DIFFERENT TYPES OF PORCELAIN FILTERS

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ABSTRACT

Dyes ions which mainly released from dyeing industries have become a serious effect to human beings and the aquatic eco-system and high using the dyes generate colored water and contaminate the aquatic environment .Reactive dyes are the most problematic among other dyes, as they can not be removed by the traditional treatment systems. Removing color from wastewater can be done via several methods. Adsorption techniques are an attractive and effective alternative treatment for dye removal from wastewater.

The reactive orange, an anionic dye that was used in this study without any purification. The solutions of dye that were prepared by dissolving a dye in deionized water to the required concentrations. Maximum absorption wavelength (λmax) and the concentration of dye were determined by UV/V spectrophotometer.

Comparative study for different types of porcelain filters made of activated kaolinite, porcelinite, sand and limestone were used for removing reactive orange dye from its solutions by using adsorption experiments. Different parameters: pH and rat outflow discharge values were used to test the efficiency of filters ability for removing the dye. All of types of porcelain filters showed efficient ability for removing the dye at different pH values and the porcelinite filter showed better ability for removing the dye than sand filter.

The removal efficiency of dye increased when the out flow discharge decreased at different pH values for the all filters. At pH 2.25 the best removal was by porcelinite filter which varies from 86.66 to 99.25% % at initial concentration of the dye, because of the high content of porcelinite. Which means that at this pH the porcelain could be very active and it could adsorb the RO dye.

Key words: Reactive orange dye, porcelain, filter, adsorption, pH

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1. INTRODUCTION

Currently more than 9000 kinds of dyes integrated in the color index . These chemicals are used in large amounts in textile, paper, leather, plastics, pharmaceuticals, and food [1, and 2] Public acceptance and aqueous solution are greatly influenced by the dye and dye is the first contamination which is detected in water the use of synthetic dyes is constantly increasing in various industries due to low cost of synthesis ,ease of use and chemical stability in comparison with other colors[3, 4, and 5].

Dyes ions which mainly released from dyeing industries have become a serious effect to human beings and the aquatic eco-system and high production and using the dyes generate colored water and contaminate the aquatic environment. Industries of textile, paper, food and tanneries, electroplating factories discharge colored water[6].

Generally, dyes that come from Industries textile are made of synthetic, organic, and aromatic chemicals that may be contained of some elements in their structure. Complex structure and presence of contaminants cause poisonous effects and may be teratogen, mutagen and carcinogen. Also they reduce light penetration and photo-synthesis [7, and 8] and pose dangerous problems to the environment because of their low biochemical oxygen demand (BOD) color and high chemical oxygen demand (COD). Vinyl sulfone and chlorotriazine dyes create the largest important class of the commercial dyes in contaminated water. These dyes can be used for, paper, silk ,cotton, rayon, and wood but not for synthetic fibers. They are mostly non-biodegradable and resistant to destruction by conventional wastewater treatments [9].

Generally, reactive dyes are the most problematic among other dyes, as they can not be removed by the traditional treatment systems. Removing color from wastewater can be done via several methods. Chemical methods use the coagulation and flocculation that combine with floatation, filtration, precipitation –flocculation, electro-floatation, electro-kinetic coagulation and ozonisation to remove color. Physical methods are often applied the membrane filtration and adsorption techniques [4].

Adsorption techniques are an attractive and effective alternative treatment for dye removal from wastewater. There are many advantages of adsorption techniques, such as lower sensitivity to diurnal variation, less land area (half or a quarter of what is required in a biological system), greater flexibility in the design not getting affected by toxic chemicals and operation and superior removal of organic pollutants [10, 11, and 12].

2. MATERIALS AND METHODS

The materials that are used in experiments to produce three types of porcelain filters were made of Kaolinite , Porcelinite, Sand and Limestone. The first was made by mixing 50% of Kaolinite and 50% of Porcelinite with few of Limestone (P1).The second was made by mixing 25% of Kaolinite and 75% of Porcelinite with few Limestone (P2). While the third was made by mixing 50% of Kaolinite with 50% of Sand and few of Limestone (P3). The porcelain filters were shaped as cylindrical filters with a diameter 5 cm and thickness 1 cm, by semiarid modus operandi.

The porcelains materialistic characteristics were tested according to ASTM-C373 Standards ,2006,[13]. The materialistic characteristics for the three filters (P1, P2, and P3) were: apparent density,1.48, 1.29, and 1.5 gm/cm^3, apparent porosity, 47.14, 51.47, and 31.88, ,true porosity, 14.9, 17, and13.8, water absorption, 31.82%, 39.95%, and 21.26% , and hydraulic conductivity, 0.0024, 0.0032, and 0.0018 m/hr, respectively.

Adsorbate

Reactive Orange Dye (RO)

The RO, an anionic dye that was used in this study was from Al-Hilla Textile Factory. It was used without any purification. The solutions of dye that were prepared by dissolving a dye in deionized water to the required concentrations. A calibration curve of absorbance against concentration was created by a UV-Vis Spectrophotometer Optima SP 3000 nano. The maximum absorbance wavelength (λ_{max}) of RO was 475 nm. Fig:1 showed calibration curve for RO dye concentrations versus absorbance.

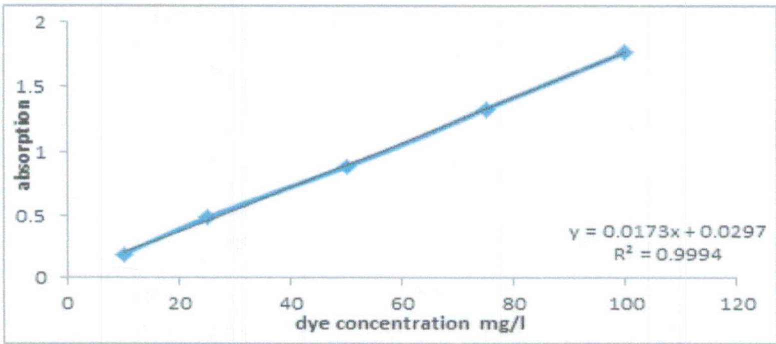

Figure 1 Curve of calibration for RO dye concentrations versus absorbance.

Adsorption Test

A series adsorption experiments were carried out for each produced porcelain filter at room temperature by passing 250 ml of RO solution (100 mg/l) at its natural pH(6) through the porcelain filters. The concentrations of solutions measured by before and after passing through filters. The test was started with 25cm RO dye solution column, which led to average water discharge 1.67ml/hr.

pH Effect

The initial pH effect on the removal percentage of the dye from its solutions was investigated by using different initial pH values (2.25 , 4.5 , 6.0, 7.5, 9.1, 10.5) at constant parameters. The solutions initial pH were adjusted to the required values by addition few drops of 1 M HCl or/and 1 M NaOH [14]. There was no change in the wavelength which indicated that the molecule of RO dye did not degrade. The average discharge was 1.67ml/hr.

The removal percentage of the dye calculated by the following expression [15].

$$Rd = \frac{Co-Ce}{Co} \times 100 \quad (1)$$

Where: Rd is the percentage of removal of the dye, *Co* and *Ce* are the initial and final dye concentrations (mg/l) respectively.

Discharge Effect

Twenty four adsorption experiments were carried out to know the ability each of porcelain filter for removing RO dye 100 mg/l from its aqueous solutions , including three replications at four discharges (0.26, 0.44, 0.88, 1.67 ml/hr) and six inflow pH (2.25 , 4.5 , 6.0, 7.5, 9.1, 10.5) values. The average discharge (ml/hr) of solutions passed through the porcelain filters was investigated by measuring the volume of filtered solution passing out of the porcelain filter at a certain time. The solution discharge was used as indicator of contact time between the dye of RO and the porcelain filter. The high discharge value means low contact time and vice versa.

3. RESULTS AND DISCUSSION

Adsorption Test

The porcelain filters efficiency for removing the RO dye(100mg/l) from its aqueous solutions at natural pH 6 were tested.

The results showed that all types of filters could adsorb some of the inflow dye. The outflow concentrations of RO dye through P1, P2, and P3 were 81.28, 86.82, and 91.09 mg/l, respectively, which means that all types of filters could adsorb (removing from its aqueous solutions) RO dye with different percentages at natural pH value. This difference could be attributed to the variety in composition of porcelain filters.

pH Effect

Fig: 2 showed the removing efficiency of the dye by P1 increased at higher and lower pH values. If the dye solutions pH increased from 6.0 - 7.5, the removal percentage of the dye was increased from 3.6% - 4.89%. And when pH values increased to 9.1 and 10.5 the dye removal percentage was increased to 17.78% and 52.99% respectively. While the pH of the solution decreased from 6.0 - 4.25 and 2.25 the dye removal percentage increased from 13.6% - 25.33 and 68.72% respectively.

The same behavior was observed for P2 and P3. The removing efficiency of the dye by P2 increased at higher and lower pH. If the dye solution pH increased from 6.0 - 7.5 the dye removal percentage decreased from 18.72% to 8.33%. Then when pH values increased more to 9.1 and 10.5 the dye removal percentage increased to 26.65% and 63.4% respectively. While the pH of the solution decreased from 6 to 4.25 and 2.25, the dye removal percentage increased from 18.72% to 29.2 and 86.66% respectively. The removing efficiency by P3 increased too when the pH increased or decreased more or less than 7.5. When the dye solution pH increased from 6.0 - 7.5 the percentage of dye removal decreased from 8.99% - 2.84%. Then if pH increased more to be 9.1 and 10.5 the dye removal percentage increased to 14.23% and 17.72% respectively. While the pH of the solution decreased from 6 to 4.5 and 2.25 the dye removal percentage increased from 8.99% to 10.37 and 21.21% respectively.

Generally, the results showed that the three filters can remove RO dye from their solutions at natural conditions, but they differ in percentage of removal. It has been noticed that the filter which contains porcelinite in its composition has better ability of removing RO dye, than that without porcelinite. P3 which contains sand has lower ability of removing the dye from its solutions.

RO dye are identified to ionized in aqueous solutions to form anions due to the sulfonate groups in their arrangements .Two sulfonate (SO_3-) groups of RO dye are easily dissolved and have negative charges in water environment. If pH of the system decrease ,the protonated surface group (Si-O-N^+H_2-C) will facilitate the adsorption of negatively charge dye. The number of positively charged sites which increased result in an increase of binding sites for anionic dye molecules [16]. The optimum pH value was attained at pH 2.25. That means when pH value of the solution be in acid or in alkaline range. This behavior refers to the original component of (P1, P2, and P3) which is composed of Kaolinite ($Al_2Si_2O_5(OH)_4$

,Quartz (SiO_2), Low Cristobalite (SiO_2), Tridoymite (SiO_2) and Calcite ($CaCO_3$), respectively [17]. The structure of Kaolinite is a gibbsite sheet with a single tetrahedral silica sheet, and its water is present as H^+ and OH^- ions [18, and 19]. When the filter mixture heated to 1200 C° water would evaporated. So hydrogen ions and hydroxyl groups could leave their positions with missing positive and negative charges. When water with acidic or alkaline pH passes through porcelain, it will lose the effective positive and negative groups by adsorption phenomena.

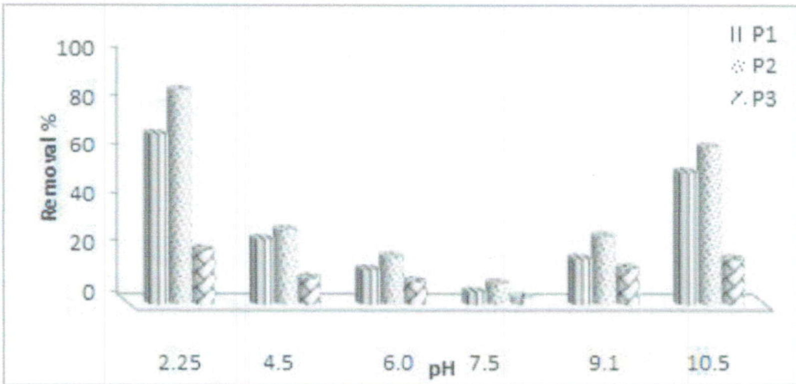

Figure 2 The initial pH effect on RO dye removal percentage.

Discharge Effect

Generally, the results of Figs 3-8 showed that all the filters could remove RO dye when the solutions that passing at different discharges. The removal percentage efficiency of dye increased when the discharge decreased at different pH values for the all filters. At pH 2.25 the removal by P1varies from 68.72 to 96.1% at initial concentration of RO dye. While P2 could remove the dye from 86.66 to 99.25% of RO dye initial concentration. The percentage of removal by P3 alter between 21.21 and 61.41% at initial concentration of RO dye. Which means that at this pH the porcelain could be very active and it could adsorb the RO dye, and the best filter is P2 because of the high content of porcelinite. While at pH 10.5 the removal percentage of RO dye by P1 varies between 52.99 % and 90.55 %. And removal percentage efficiency by P2 alter between 63.40% and 91.16%.. While P3 could remove the dye between 17.72% and 87.63%.

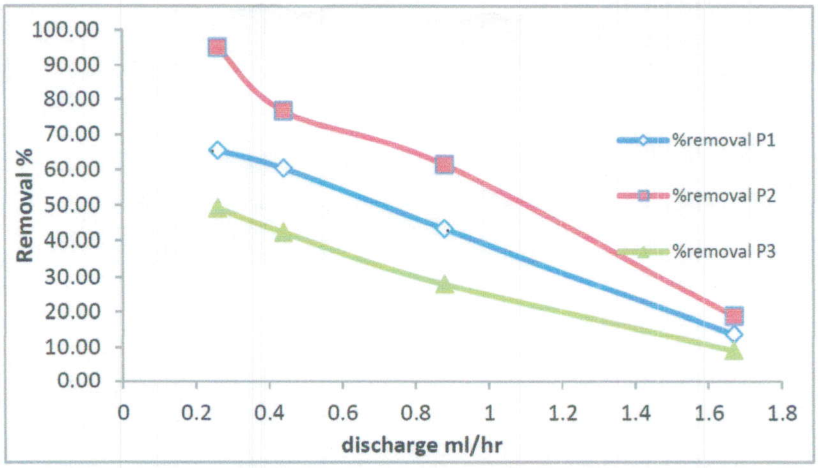

Figure: 3 Discharge effect (ml/hr) on RO dye removal percentage at pH 2.25

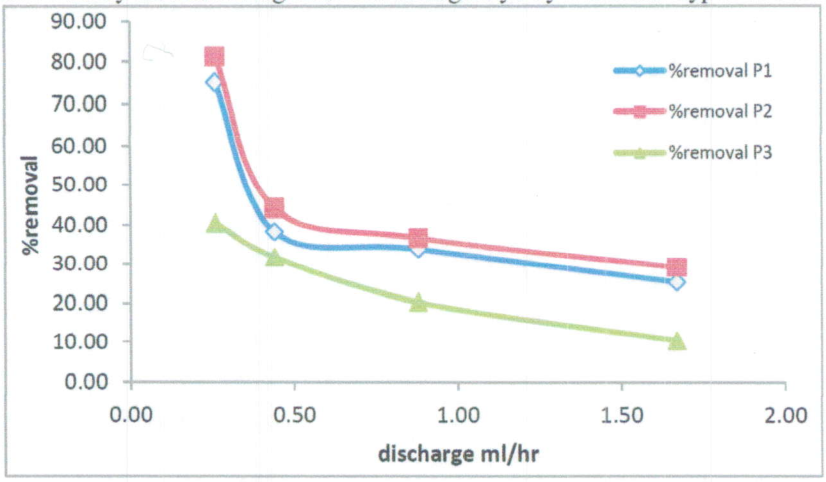

Figure 4 Discharge effect(ml/hr) on RO dye removal percentage at pH 4.5

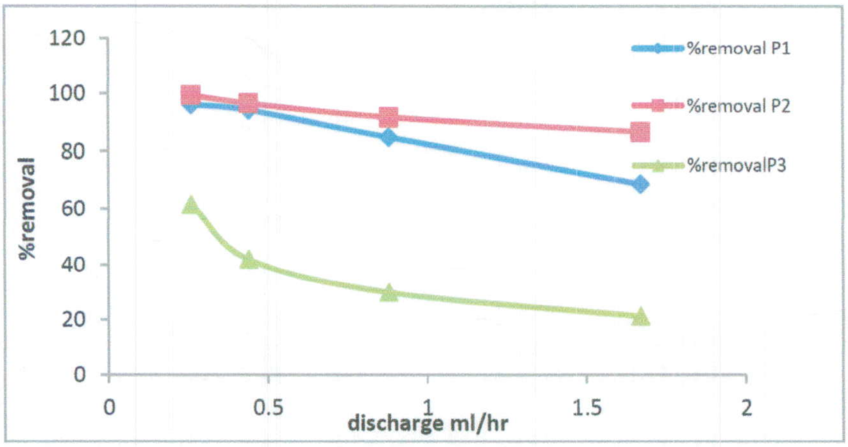

Figure 5 Discharge effect (ml/hr) on RO dye removal percentage at pH 6.0

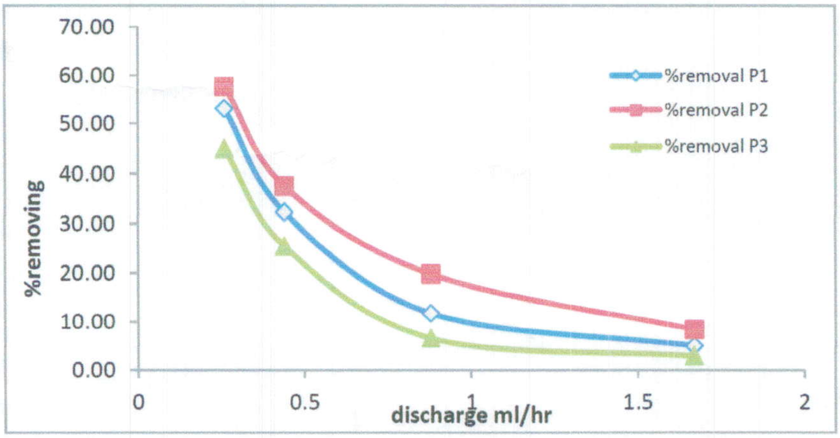

Figure 6 Discharge effect (ml/hr) on RO dye removal percentage of at pH7.5

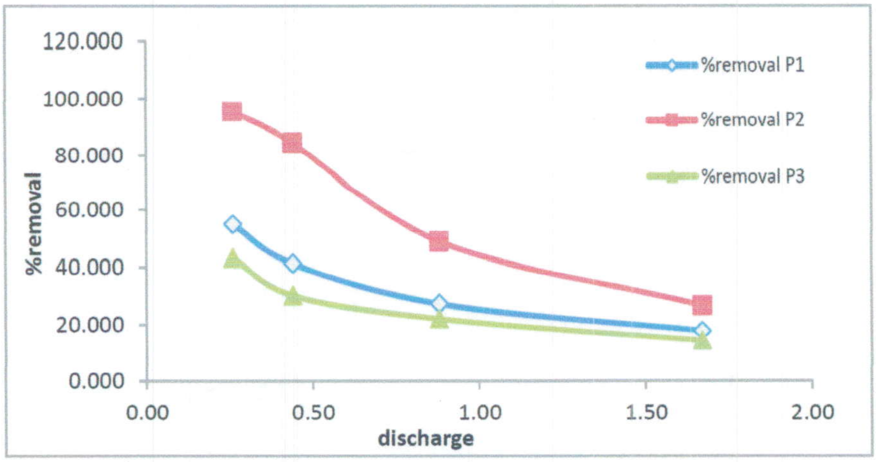

Figure 7 Discharge effect (ml/hr) on RO dye removal percentage of at pH 9.1

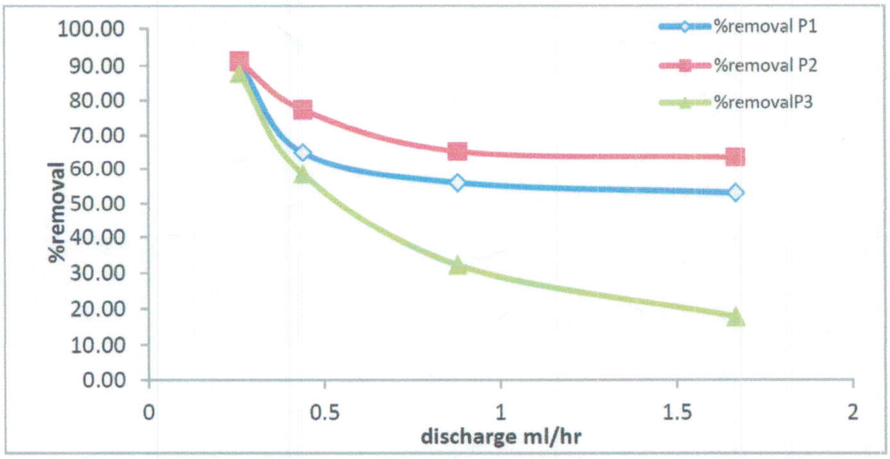

Figure 8 Discharge effect (ml/hr)on RO dye removal percentage of at pH10.5

Adsorption Capacity

The adsorption capacity of each porcelain filter was measured by the following expressions [20] .

$$A.C. = \frac{wr}{wp} \qquad (2)$$

Where: A.C.= adsorption capacity of porcelain sample.

wp= weight of porcelain sample.

wr = weight of removed dye (μg), is calculated as follows:

$$wr = (co - ce) * v \qquad (3)$$

v= volume of purified water passed the porcelain sample

The maximum adsorption capacity of each sample at different pH was shown in table(1). The results showed that the max. capacity could be reached at pH 2.25 for the three filters. P2 filter has the maximum capacity value among the three for the same reason that was mentioned above.

Table 1 maximum adsorption capacity (μg /gm)of porcelain samples at different pH values.

Initial pH of solution	2.25	4.5	6	7.5	9.1	10.5
Max. ads. Capacity of P1(μg /g)	3.94	3.41	2.49	2.42	2.91	3.46
Max. ads. Capacity of P2(μg /g)	4.53	3.71	3.34	2.62	3.67	4.23
Max. ads. Capacity of P3(μg /g)	3.24	2.44	2.09	2.17	2.37	2.97

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