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Isotherm, Kinetics and Trickling Flow Studies for Removal of Chromium from Synthetic Effluent by using Mixed Fruit Peels (MFP)

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Abstract*: *Chromium is used for various applications in chemical, leather, paint, dyes and many other industries. Effluent from these industries contains considerable amount of chromium. Removal of chromium from the effluent is very important aspect of investigations on wastewater treatment. In the present investigation mixed fruit peels (MFP) are used as biosorbent for chromium removal. These fruit peels are used in batch operations to study isotherm and kinetics. It was observed that the chromium removal followed first and second order kinetics. The R^2 values more than 0.94 for both indicated excellent fit to the kinetic equations. In case of isotherms, the data followed both, Freundlich and Langmuir isotherm. Then these are used in trickle beds to study the effect of various parameters on the removal efficiency. The break through time was (time required to reach 10 percent of original concentration) 13, 24, 35 for the flow rates 120, 80 and 40 ml/min for initial concentration of 1000 mg/l. It was observed that for change in the concentration from 500 to 250 mg/l, the breakthrough time delays. It again decreases for 100 mg/l.

Index Terms: **Adsorbate, concentration, Freundlich, Langmuir, order, time.**

I. INTRODUCTION

Chromium is used for various applications in chemical, leather, paint, dyes and many other industries. Effluent from these industries contains considerable amount of chromium. Removal of chromium from the effluent is very important aspect of investigations on wastewater treatment. Various investigations are reported on physicochemical and biological methods for chromium removal from wastewater. Removal of chromium from effluent can be carried out by various biological, chemical and physico-chemical methods. The biological removal of heavy metals from effluent can be carried out in activated sludge process and trickling filters. Trickling filters for heavy metal removal resembles to packed bed biosorption. Many investigations are reported on use of waste materials for biosorption (Nagda et al., 2008; Kulkarni, 2016; Sugasini et al., 2014) [1-3]. Various materials such as fruit waste (Hema Krishna, 2014; Schiewer and Patil, 2008; Abbasi et al., 2013), tea waste (Malkoc and Yasar Nuhoglu, 2005), waste seeds (Gohulavani and Andal, 2013; Abdi and Kazemi, 2015), sawdust (Kulkarni et al., 2013) have been used for heavy metal removal by various investigators [4-10]. Biological chromium (VI) removal from industrial wastewater by using a pilot-scale trickling filter was studied by Dermou et al. (2005) [11].Three modes namely batch, continuous and sequential batch reactor (SBR) with recirculation were incorporated in the investigation. They found that operation with recirculation was very effective operating mode. It ensured even wetting of the filter and distribution of the precipitates all over filter volume. Nourmohammadi et al. investigated efficiency of total nitrogen removal in activated sludge and trickling filter processes (2013) [12]. Ahemad et al. carried out studies on chemically enhanced trickling filter (2007) [13]. According to these studies, about 80 % of the biological pollution load can be removed by the upstream chemical treatment at an optimal dose. Soontarapa and Srinapawong proposed trickling filter with a chitosan membrane coated matrix (2001) [14]. They observed that a chitosan membrane on trickling filter matrix can improve the wettability and enhance the adherence of microorganisms useful for wastewater treatment. Logan et al. studied the models for trickling filters (1987) [15]. They assumed first order uptake kinetics and laminar flow in thin films. Their trickling filter model successfully predicted the biological oxygen demand removal in plastic media trickling filters. A laboratory scale trickle-bed reactor was used for catalytic wet air oxidation of wastewater by Uraz and Atalay (2013) [16]. They determined the optimum operating conditions for the reaction of phenol in the wastewater with oxygen using a catalyst. They observed that with increasing temperature, pressure, gas flow rate and liquid space velocity, the phenol conversion increased. It decreased with initial concentration. Simultaneous Cr (VI) reduction and phenol degradation in a trickle bed reactor system was studied by Chirwa and Smit (2010) [17].They obtained 70 percent removal for chromium and 80 percent for phenol. Peat bed filters were used by Patterson for on-site treatment of septic tank effluent (18). They obtained faecal coliforms (FC) reduction by 99.46%, total nitrogen (TN) by 44.2% and total phosphorus by 83.6%.

According to Kandasawamy et al. (19) biofiltration is efficient method for waste treatment. They emphasized the importance of the maintenance of microorganisms in treatment facility. Biofiltration methods for treatment of heavy metals were explored by Shrivastava and Majumdar (2007) [20]. They predicted high possibility for effective application of biofilters for removal of toxic heavy metals. Biofiltration of Cu (II) using acclimated mixed culture developed from activated sludge was used by Gangadhara et al. (2012)[21]. The results showed 91.5% removal of copper ion for 40 mg/l of inlet concentration of copper. Removal of heavy metals from synthesis industrial wastewater using local isolated candida utilis and aspergillus niger was investigated by Ali (2013)[22]. They obtained optimum removal efficiency of chromium, lead, and nickel as 89%, 90%, and 91% for Aspergillus Niger bio-filter. The removal efficiency was 81%, 83%, 80% for Candida Utilis bio-filter. The optimum condition was, pH 6, residence time 10 min, flow rate 9 ml/min. The effect of drying and subsequent rewetting on the retention of heavy metals in storm water biofilters was investigated by Blecken et al. (2008)[23]. This research indicated that extended drying decreases metal removal from storm water. In the present investigation mixed fruit peels (MFP) are used as biosorbent for chromium removal. These fruit peels are used in batch operations to study isotherm and kinetics. Then these are

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used in trickle beds to study the effect of various parameters on the removal efficiency.

II. METHODOLOGY

For studying kinetics, experiments were carried out in 250 ml conical flask and with 100 ml of synthetic effluent prepared by adding potassium dichromate in water. Then 4 grams of fruit peels were added and stirred for appropriate time. The chromium concentration at various time intervals was determined by spectrophotometric method. For isotherms, experiments were carried out with 1, 2,3,4,5, and 6 grams of MFP and 500 mg/l initial concentration. The concentration was measured after equilibrium was attained. In continuous experiments, the MFP was used in trickle bed. Experiments were carried out by varying flow rates (40, 80, 120 ml/min). Also at optimum flow rates, another set of experiments was performed by changing initial concentrations (500, 250, 100 mg/l). Trickle bed experiments were carried out with and without aeration to study effect of aeration on the removal. Also experiments were carried out at different MFP sizes to study effect of size on the removal.

III. RESULT AND DISCUSSION

A. Batch Experiments, Isotherm and Kinetics

Effect of contact time on final concentrations is shown in fig.1. It can be observed that initially the removal is rapid followed by slow removal. As time is increased, gradually the concentration attained constant value. It indicates that the capacity of the MFP to remove chromium is exhausted. Optimum contact time was three hours.

For first order kinetics, $q_e - q_t$ was plotted verses time. q_e is adsorption capacity at equilibrium and q_t is adsorption capacity at any time(mg adsorbed per gm adsorbent). The plot of t/q_t verses t indi cates second order equation. For Freundlich isotherm, x/m(mg adsorbed/gram adsorbent) was plotted against C^*, equilibrium concentration of adsorbate on logarithmic scale. The plot of $1/(x/m)$ against $1/C^*$ was plotted for Langmuir isotherm.

As shown in fig.2and 3, it was observed that the chromium removal followed first and second order kinetics. The R^2 values more than 0.94 for both indicated excellent fit to the kinetic equations. In case of isotherms, the data followed Both, Freundlich and Langmuir isotherm (Fig.4 and 5). This indicates possibility of multilayer adsorption and some chemisorption phenomenon.

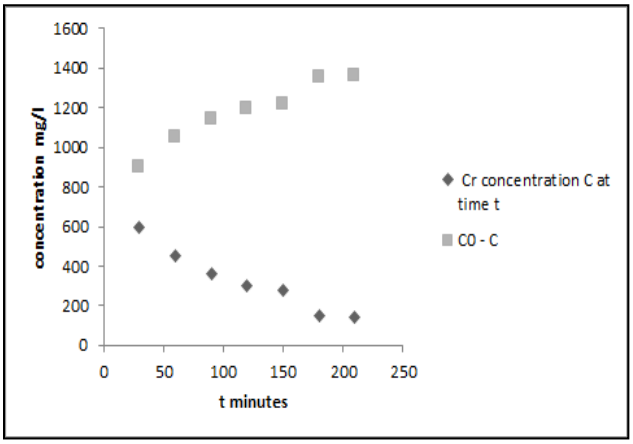

Fig. 1: Chromium removal and contact time

B. Continuous Experiments

A shown in Fig. 6, the break through time was (time required to reach 10 percent of original) 13, 24, 35 for the flow rates 120, 80 and 40 ml/min for initial concentration of 1000 mg/l. It can be observed that the break through time delayed as the flow rate decreased. Rapid availability of the adsorbate can be reason for this. With constant flow rate 120 ml/min, the experiments were conducted at initial chromium concentrations 500, 250 and 100 mg/l. It was observed that for change in the concentration from 500 to 250 mg/l, the breakthrough time delays (Fig.7). It again decreases for 100 mg/. Experiments carried out with aeration indicated 3 – 8 percent increase in the removal. This indicates that the aeration has very little effect on the removal. Biosorption is major phenomenon in chromium removal by MFP. The chromium removal increased with reduction in size from 2 cm to 1 cm. Further reduction in size has adverse effect on the removal (Fig.8). For initial decrease in size, more surface is available due increased number of sites. If the particle size is too small, adverse effect is observed on removal due to hindrance of small size adsorbent material. All the available surface area cannot be utilized efficiently.

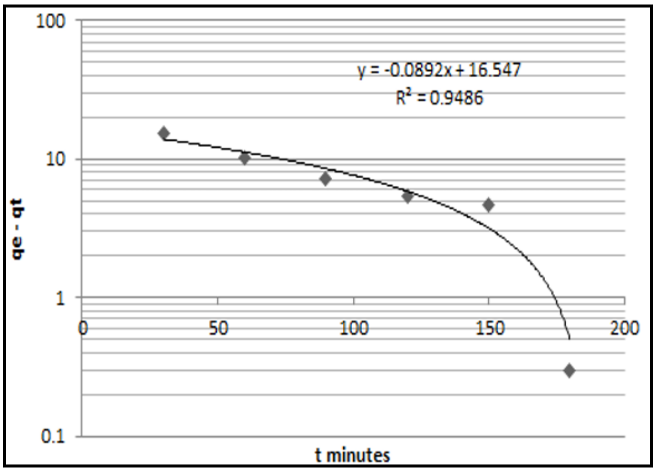

Fig.2: First order kinetics

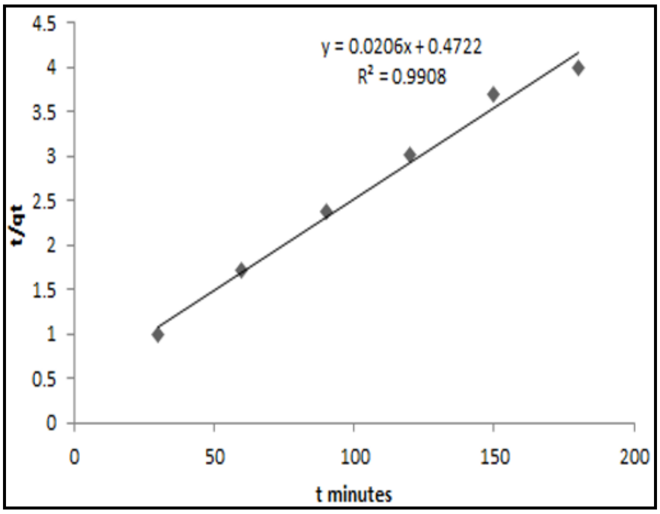

Fig 3: Second order kinetics

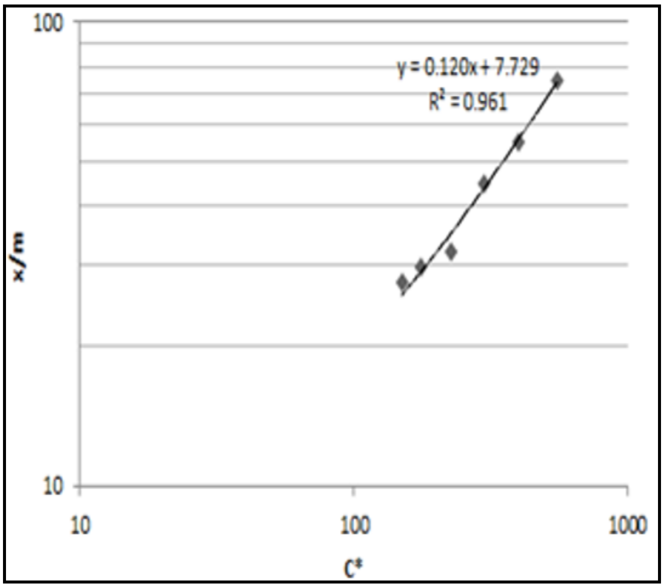

Fig.4: Freundlich isotherm

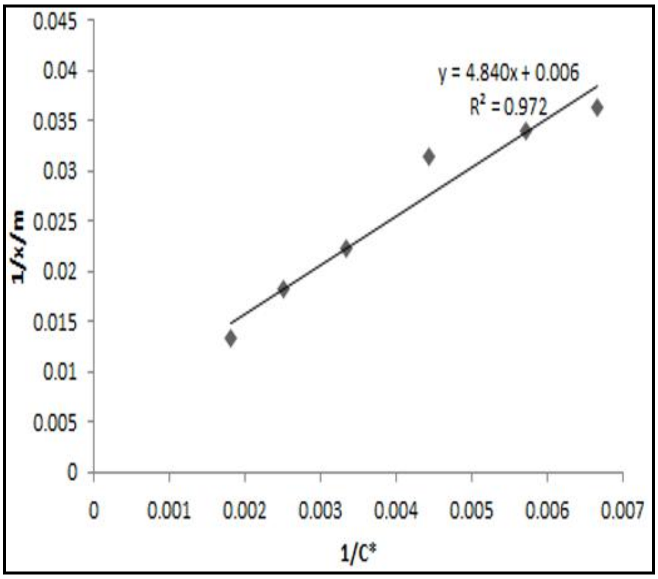

Fig.5: Langmuir isotherm

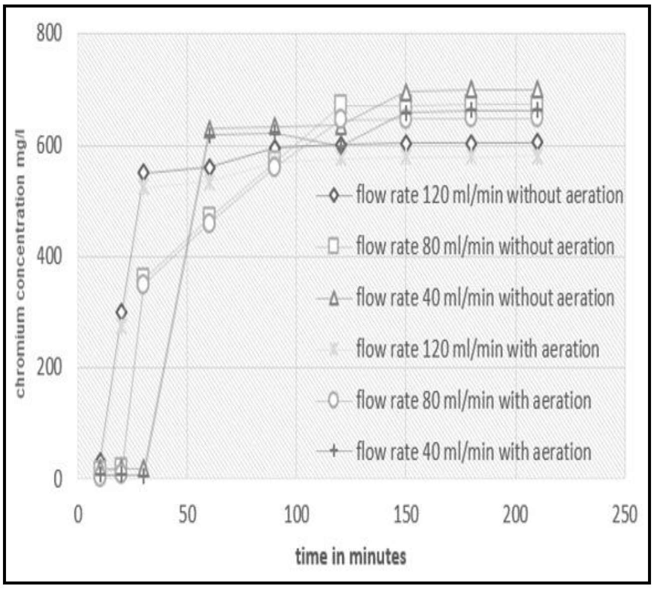

Fig.6: Effect of flow rate

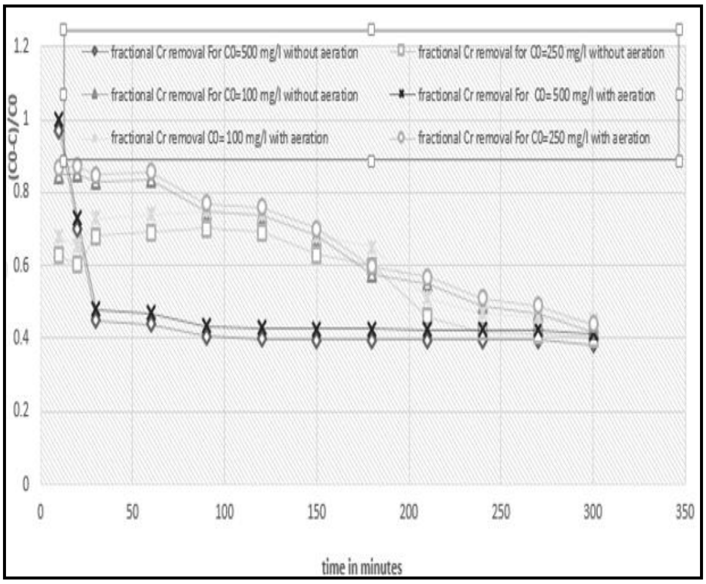

Fig.7: Effect of initial concentration

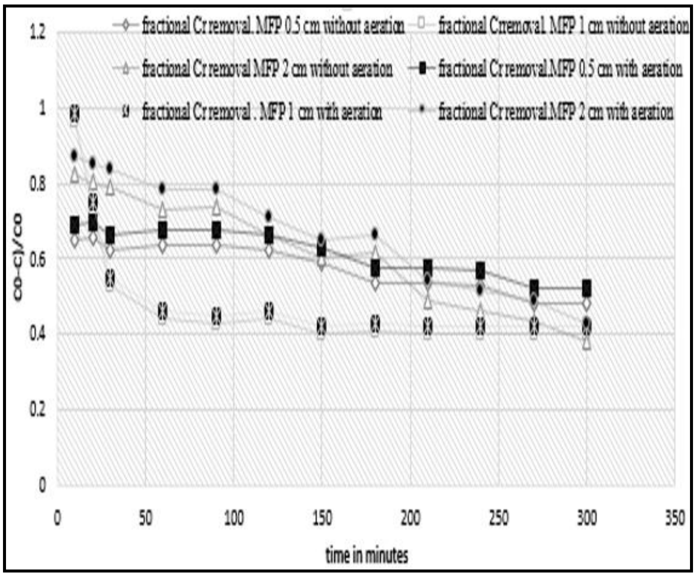

Fig.8: Effect of MFP size

IV. CONCLUSION

In the present investigation mixed fruit peels (MFP) are used as biosorbent for chromium removal. These fruit peels are used in batch operations to study isotherm and kinetics. It was observed that the chromium removal followed first and second order kinetics. The R^2 values more than 0.94 for both indicated excellent fit to the kinetic equations. In case of isotherms, the data followed both, Freundlich and Langmuir isotherm. Then these are used in trickle beds to study the effect of various parameters on the removal efficiency.

The break through time was (time required to reach 10 percent of original concentration) 13, 24, 35 for the flow rates 120, 80 and 40 ml/min for initial concentration of 1000 mg/l. It was observed that for change in the concentration from 500 to 250 mg/l, the breakthrough time delays. It again decreases for 100 mg/l. In most of the experiments, the removal was above 90 percent. It can be concluded that use of mixed fruit peel is efficient method for chromium removal from wastewater.

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