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CONTINUOUS ACTIVATED SLUDGE TREATMENT FOR NICKEL REMOVAL FROM EFFLUENT: INVESTIGATION ON AFFECTING FACTORS

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ABSTRACT

Nickel is one of the important heavy metals used in various industries such as plastics manufacturing, metal finishing, nickel-cadmium batteries, fertilizers, pigments, mining and metallurgical operations. Nickel can be removed by adsorption, ion exchange, membrane separation, chemical precipitation and biological methods. Biological methods include activated sludge process and trickling filter process. Activated sludge process is effective and environment friendly. Its serves the purpose of treating waste by using waste thereby minimizes the solid waste.In the current investigation, effect of various parameters such as flow rate, initial concentration, sludge age, sludge concentration on nickel removal is reported.

Keywords:Sludge, concentration, flow rate, parameters, sludge age, fractional removal.

I INTRODUCTION

Presence of heavy metals in wastewater is effect of many industrial applications of heavy metals which are key to many chemical and mechanical industries. The presence of heavy metals and organic matter can cause various short term and long term diseases. Heavy metals present in waste water and industrial effluent is major concern of environmental pollution. Nickel is one such heavy metal. Nickel can be removed by adsorption, ion exchange, membrane separation, chemical precipitation and biological methods. Biological methods include activated sludge process and trickling filter process. Activated sludge process is effective and environment friendly. Its serves the purpose of treating waste by using waste thereby minimizes the solid waste. In the current investigation, effect of various parameters such as flow rate, initial concentration, sludge age, sludge concentration on nickel removal is reported.

II LITERATURE REVIEW

Benaissa and Elouchdi used dried activated sludge for the removal of copper ions from aqueous solutions(1).The aim of their research was to obtain the basic information to the design of sorption equipment, i.e. kinetic data and equilibrium in batch system. In this work, biosorption of copper from aqueous solutions, by dried activated sludge in single metal solutions was investigated in a well-stirred batch reactor. Danesh et.al.used microwaves for generation of exceptional quality biosolids for phosphorus and heavy metal extraction from wastewater treatment plant sludge(2). The aim of the study was to evaluate how much phosphorus and metals in sludge can be released into solution by microwave irradiation when applied to sludge prior to anaerobic digestion, and to determine the effectiveness of subsequent lime precipitation. It was observed that Phosphorus release from thickened PS/WAS or un thickened WAS was proportional to both the temperature and duration of heating. Rahmaniet.al worked on removal of lead by using waste activated sludge.(3). The lead removal efficiency increased upto first 45 minutes and remained constant thereafter for initial concentration of 5 g/l. When continuous aeration was provided, that marked increase in removal efficiency, but considerable increase in the contact time. Sorption of co^{2+} , zn^{2+} , cd^{2+} and cs^{+} ions by activated sludge of sewage treatment plant was studied by Maresova (4). The process of metal uptake was not inhibited because of pretreatment with formaldehyde or deactivation at 60°C. It means the sorption of metals was not dependent on the metabolic activity of the sludge. Metal cationbiosorption is diminished below pH 4 sorption efficiency of activated sludge increases above pH 8.

Investigation of the effect of heavy metals on the activated sludge activity was carried out by Ong et.al. (5). They evaluated the inhibitory effect of heavy metals on the activity based on dissolved oxygen and specific oxygen uptake rate(SOUR). Fixed activated sludge system for treatment of wastewater containing heavy metal compounds like chromium, lead and Nickel was used by Hasani et.al. (6).They studied compatibility and performance of fixed activated sludge reactor(FAS).Their study revealed that COD removal efficiency in the FAS is about 96% and the acclimation time for microorganisms is short. Pagnanelli et.al studied Mechanism of activated sludge process (7). They carried out research on chemical mechanism of cadmium and lead removal by activated sludge process. They found that the carboxylic and amino groups are two main groups responsible for the binding properties of the biomass. Atkinson et.al used waste sludge as a biosorbent for heavy metal treatment(8). The metal plating effluent was treated by activated sludge remediation. They also studied desorption studies and estimated desorption efficiency. They concluded that bioadsorption of heavy metals by activated sludge in mixed-metal streams occurs in a non-specific fashion, with preference shown towards those metals which are present in the greatest concentrations and sludge-bound metals can also be effectively desorbed using mineral acids. Niec et.al.studied the influence of anoxic selectors on heavy metal removal by activated Sludge(9). They compared the metal binding characteristics of an an-oxic selector activated sludge system with a conventional activated sludge system. It was observed that, from sorption isotherm the selector sludge had significantly higher sorption capacity than did the control sludge. The solute uptake followed Freundlich isotherm model for equilibrium concentrations. ECP-producing bacteria (i.e., Zoogloea sp.) by the selector system may be gives the higher metal sorption capacity of selector sludge. Oviedo et al. studied The toxic effects of the metals cadmium, zinc and copper on microbial activity in the activated sludge process (10).

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The presence of the metal led to a decrease in the rate of organic material elimination throughout the duration of the experiment. They concluded that that cadmium is the most highly toxic metal for the microbial communities present in the activated sludge process, followed by copper, and lastly zinc. Suoet.al carried out the research on immobilization of heavy metals on activated sludge (11). They used Calcium alginate beads to immobilize the sludge. copper, zinc and chromium sorptions were carried out. The adsorption rate of pretreated activated sludge was higher than immobilized sludge. The sorption metal uptake followed Langmuir isotherm. The removal of heavy metals ions from wastewater with conventional activated sludge process was investigated by Jalilzadeh and Parvaresh (12). According to standard limits of Iran, in this comparison, some metal concentration of effluent was higher. They concluded that conventional activated sludge process alone cannot remove heavy metal sufficiently.

III METHODOLOGY

Studies were carried out at various values of parameters namely flow rate, initial nickel concentration, sludge age and sludge concentration. Samples were collected and analyzed after every 10 minutes. The final concentration(C/C0) was studied at various times. Also breakeven time and exhaustion time was studied. These experiments were carried out with and without aeration. Since the tank includes cylindrical as well as conical shapes the dimensions are as follows: Dimensions for cylinder-Diameter of cylinder = 25 cm, Length of cylinder = 27 cm, Dimensions for cone-Diameter of cone = 25cm,Length of cone = 13cm.

IV RESULTS AND DISCUSSION

Activated Sludge Process Studies without aeration was carried out and experimental readings are summarized and tabulated in Table No. 1. This data is subsequently used to plot the graphs to present the results.

4.1 Effect of Flow Rate for ASP without Aeration

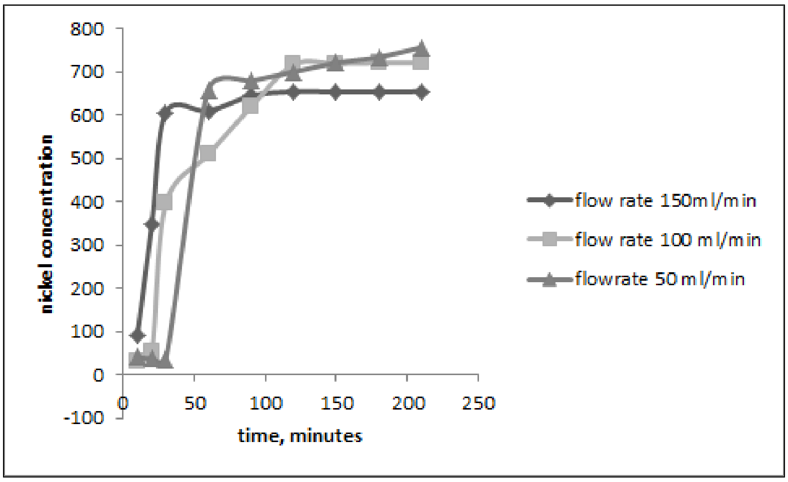

Fig.4.1: Effect of Flow Rate for ASP without Aeration

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As shown in Fig. 4.1, the saturation was reached in 95, 125 and 167 minutes respectively for flow rate of 150, 100 and 50 ml/minutes. The optimum flow rate was taken as 100 ml per minutes based on the overall removal and time taken for exhaustion. The percentage removal obtained was 3 to 5 percent less than Trickling Filter experiments with Aeration and it was 2 percent lower than the Activated Sludge Process (ASP) experiments with Aeration.

4.2 Effect of Initial Concentration for ASP without Aeration

With increase in the initial concentration the time required to reach break point and the exhaustion concentration decreases. The rapid and fast availability of the adsorbate can be the reason for this. The increase in concentration beyond certain value doesn't have any positive effect on percentage removal. The dense influent many have high concentration, but inadequate contact may affect the percentage removal. The percentage removal obtained was 4 to 5 percent less than Trickling Filter experiments with Aeration and it was 2 percent lower than the activated sludge process experiments with Aeration.

Table 1: Activated Sludge Process without Aeration (Continuous Studies)

ACTIVATED SLUDGE PROCESS WITHOUT AERATION (CONTINUPOUS STUDIES)							
Effect of flow rate Initial C_0=1000 mg/l, pH=6 on exit conc.				Effect of initial concentration(C_0) on fractional removal			
Time,min/ flowrate	150	100	50	Time,min. /conc.mg/l	1000	500	250
10	92	30.5	40.4	10	0.788	0.488	0.655
20	346	52.5	36.4	20	0.534	0.482	0.651
30	606	396.5	35.4	30	0.274	0.481	0.635
60	610	509.5	659.4	60	0.27	0.48	0.591
90	645	619.5	679.4	90	0.235	0.47	0.555
120	655	717.5	700.4	120	0.225	0.462	0.495
150	654	719.5	721.4	150	0.226	0.4	0.435
180	654	721.5	734.4	180	0.226	0.37	0.391
210	655	721.5	757.4	210	0.225	0.27	0.355
240				240	0.225	0.26	0.315
270				270	0.224	0.26	0.295
300				300	0.224	0.26	0.235
Effect of Sludge Age on fractional removal				Effect of sludge concentration on fractional removal			
Time min./sludge age	5 days	10 days	15 days	Time,min. /sludge conc.	25 g/l	50 g/l	100 g/l

10	0.45	0.773	0.598	10	0.65	0.745	0.752
20	0.446	0.529	0.586	20	0.39	0.485	0.498
30	0.42	0.33	0.57	30	0.34	0.355	0.378
60	0.418	0.253	0.522	60	0.21	0.255	0.257
90	0.408	0.23	0.494	90	0.2	0.215	0.214
120	0.406	0.22	0.43	120	0.2	0.195	0.188
150	0.34	0.211	0.37	150	0.2	0.195	0.188
180	0.314	0.21	0.326	180	0.19	0.185	0.189
210	0.206	0.208	0.302	210	0.19	0.183	0.169
240	0.202	0.209	0.254	240	0.18	0.177	0.171
270	0.202	0.209	0.238	270	0.165	0.177	0.169
300	0.202	0.21	0.17	300	0.165	0.175	0.17

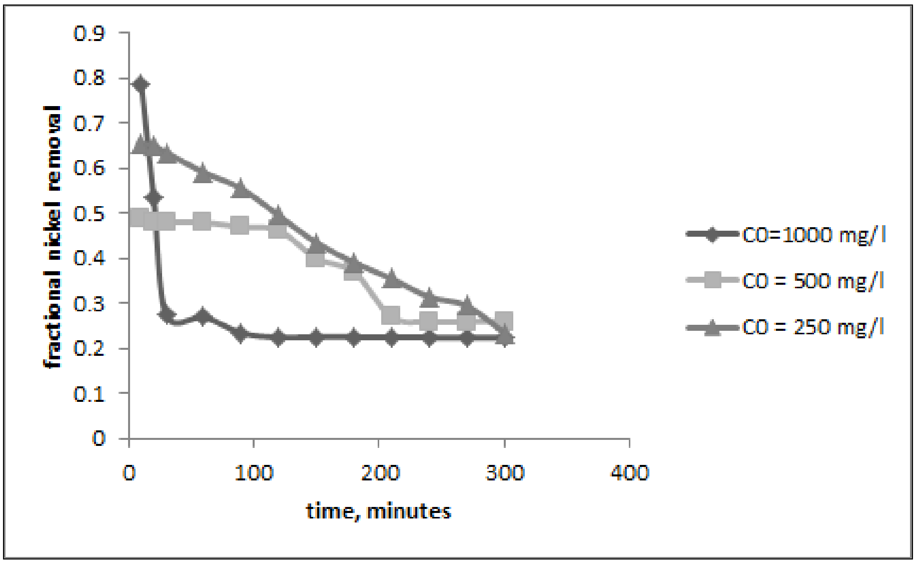

Fig.4.2:Effect of Initial Concentration for ASP without Aeration

4.3 Effect of Sludge Age for ASP without Aeration

As shown in Fig. 4.3, Sludge age had significant effect on nickel removal. The sludge age of 10 days was found to be optimum with break through time of 5 minutes. With increase in sludge age time required for breakthrough increased up to sludge age of 10 days. Further increase in sludge age has negative effect. The detachment of slime layer can be reason for this. The results indicated that percentage removal was less by 8-10 percent than similar experiments with aeration.

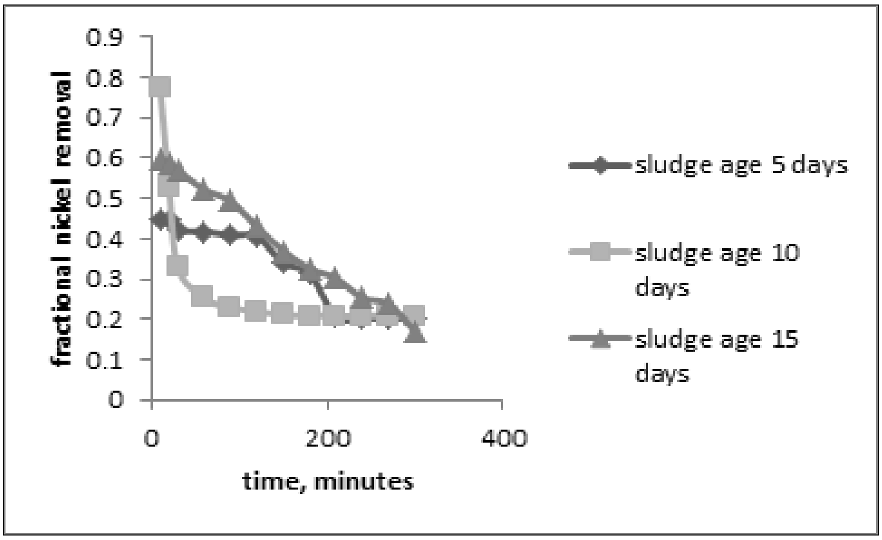

Fig.4.3:Effect of Sludge Age for ASP without Aeration

4.4 Effect of Sludge Concentration for ASP without Aeration

The sludge concentrations were manipulated by proper dilutions. Three sludge concentrations 1000, 2000 and 3000 were used in experiments. Thicker sludge has more capacity to bio-accumulate the metal. Sludge concentration variation has positive effect on Nickel removal. Sludge concentration of 2000 mg/l is enough to obtain maximum removal of Nickel. Further increase causes adverse effect on removal.Percentage removal in this case was almost 10 percent lower than that with aeration

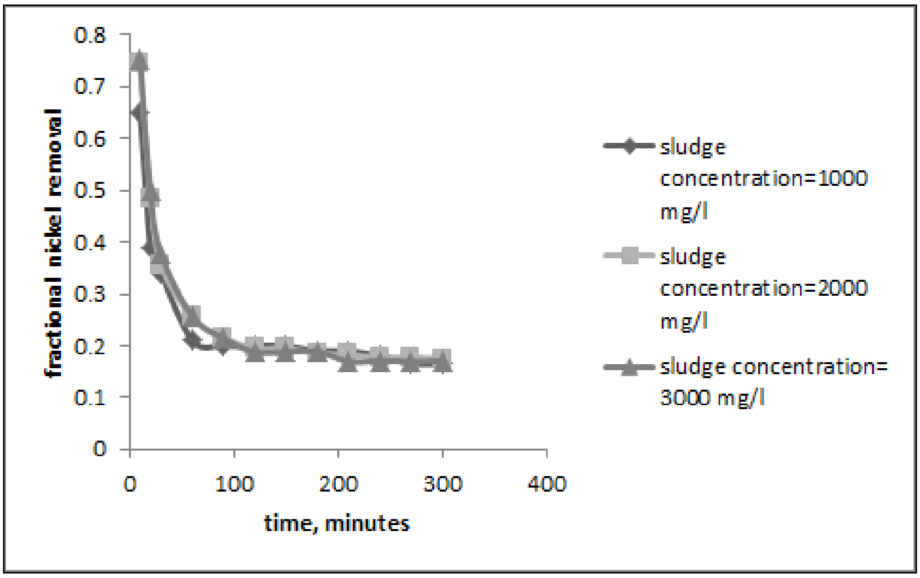

Fig.4.4: Effect of Sludge Concentration for ASP without Aeration

V CONCLUSION

In case of ASP without aeration, the optimum flow rate was taken as 100 ml per minutes based on the overall removal and time taken for exhaustion. The percentage removal obtained was 3-5 percent less than TF experiments with aeration and it was 2 percent lower than the ASP experiments with aeration. Sludge age had significant effect on removal of nickel. The sludge age of 10 days was found to be optimum with break through time of 5 minutes. With increase in sludge age time required for breakthrough increased up to sludge age of 10 days.

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