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Enhancement of Separation Efficiency for Nano Filtration Membrane using Water-Soluble Polymer.

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Abstract. In this study, an aqueous solution containing a mixture of heavy metal ion Cr(III) were treated by polymer enhanced Nanofiltration using polyethylene glycol as a binding agent polymer. The performance of PEG in removing heavy metal ion Cr (III) was compared with PEG and without PEG addition using polyamide Nano filtrationmembrane. The percentage rejection of heavy metal ions was studied under the different value of pH, metal ion concentration and flow rate. AtpH 10,percentage rejection of heavy metal ion was highest at around 99.2%,whereas,at 200ppm concentration and at 3(l/hm^2)flow rate percentage rejection of heavy metal ion with PEG was highest 99.5%,it was found that PEG gave higher percentage rejection of Cr(III) ion than without the addition of PEG.

Keywords-Nanofiltration, water soluble polymer, heavy metal, metal complex

I. INTRODUCTION

The increasing water pollution by heavy metal ion has become a series issue, because they are non-biodegradable and some of them are highly toxic and have a probable carcinogenic effect[1].The maximum contaminant level (MCL) standard for heavy metal established USA environmental protection agency is chromium 0.05 mg/l.[2].Chromium above the maximum contaminant level in water causes a problem of headache, diarrhoea, nausea, vomiting, chronic, asthma, coughing etc.[3][2].Wastewater from various industries containing heavy metal ions, which must be removed, before recycling or discharge directly in surface water, the conventional process are used for separation of heavy metal like chemical precipitation, ion-exchange, adsorption or bioseparation. [3][4].But conventionalprocesses have a significant disadvantage of incomplete removal, high energy requirement, production of toxic sludge. [5]Nowadays, membrane separation process such as microfiltration, ultrafiltration, nanofiltration, reverse osmosis and electrodialysis are significantly used for separation of heavy metals[6][7].

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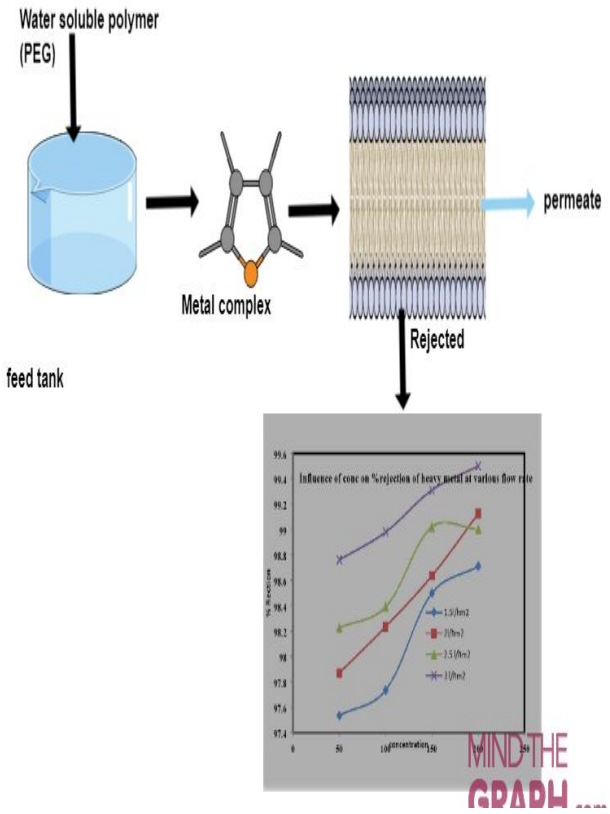
Complexation of metal ions by binding polymers is used in conjunction with nan filtration in a process known as polymer enhanced Nanofiltration.The water-soluble polymer contains one or more amine, amide, carboxylic acid, hydroxyl, phosphonic acid, quaternary ammonium salts, and sulfonic acid groups at the backbone or side chain and their abilityto remove ion pollutants from aqueous solutions.[8][9].[10]..

The complexation filtration techniques have been shown to be a promising technique towards the removal of heavy metals ions. [10][9]Separation of heavy metals from the large volume of polluted water at low concentration of heavy metal ions by conventional technique is not economically feasible and eco-friendly[1].In this case, the removal of heavy metal is more effective by complexation-nanofiltration techniques. In order to separate heavy metal ion by complexation technique, heavy metal ions formed complex with water-soluble polymer, thus, the size of metal ion increases (complex) in aqueous solution andit can separate with higher efficiency,[11][12], In previous research, ultrafiltration and microfiltration membranes was used for separation of heavy metal ions with complexation technique(water-soluble polymer),but it had disadvantages, like percentage separation efficiency waslimited which made the processes unsuitable for separation of heavy metals ions to large volume with dilute concentration[6]. the numberwater soluble polymer can use for separation of heavy metal, but polyethylene glycol hasshown good chemical stability, high efficiency and selectivity towards a separation of heavy metal ions Cr3+.[13][10][14].PEG has effective for separation heavy metal ion cr.[15]

The complexation –Nano filtration is proved to be a new promising technique for separation of heavy metals ions for dilute concentration with large volume.[16] The use of water-soluble (metal binding) polymer in combination with Nanofiltration is a hybrid approach to separate selectively and recover valuable elements of heavy metal. In complexation –NF process cationic of heavy metal ion form complexes with micro ligand in order to increase their molecular weight with size larger than the pore size of the selected membrane, that can be retained by the membrane, whereas permeate water is separated from heavy metal. The advantage of the complexation separation is high selectivity, low energy requirement and high separation efficiency. The water-soluble polymeric ligand has shown powerful substance to remove traces of heavy metal ions from aqueous solution and industrial wastewater by using membrane technique.[17]

The present work, attempt has been made to use inexpensive and easily available water soluble polymer (PEG) to formation of complex with heavy metal ion ,the objective of present work is investigate the effect of water soluble polymer PEG on separation efficiency of heavy metal ion (Cr III) using polyamide nanofiltration membrane.



II. MATERIAL.

Standard metal solutions of Chromium with the concentration of 1000 ppm were used. The complexation experiments were carried out with PEG as a water-solublepolymer. The pH of aqueous solutions was adjusted using 1M HCl and 1 NaOH.

All the chemicals were used for the experimentation work were of analytical grade and supplied by Merck. The Nanofiltration membrane module of length 40inches and diameter 4inches were used for separation.The module has consisted of cylindrical shell made up of stainless steel, and spirally wound membranes are installed in a shell. The membrane was made up of HPA (Hydrophilized Polyamide).The metal ion concentration of the synthetic solution and sample solutions after experimentation was examined using Chemito AAS 201(Atomic Absorption Spectrophotometer). The instrument was calibrated before every reading. The standard solutions prepared were used to calibrate AAS. The standard solutions were prepared from a stock solution of 1000ppm concentration by further dilution to 4, 6, 8 and 10 ppm for chromium. Calibration curves of the tested metals were constructed with different concentrations

A.Metal Complex Preparation and Separation

Initially, 15 litres of known concentration of 50,100,150,200 ppm of chromium were prepared separately;the complex of chromium was prepared from the corresponding solution using water-soluble polymer polyethylene glycol, (PEG). These metals ions and metal complexes were separated by using Nanofiltration membrane unit as shown in figure1. It consists of a feed tank (20liters capacity), The feed tank solution was passed to the membrane unit. The Nanofiltration membrane module made up of HPA (Hydrophilized polyamide), having a diameter 40 inches and length 4 inches. The module consists of a cylindrical shell made up of stainless steel and the spirally wound membrane was installed in a shell. The flow rate of feed, permeate and rejection was measured using flow meter. The operating pressure was 50-130psi. The leak check was taken at the time of backwashing. The sample collected from permeates and rejected was measured continuously using atomic absorption spectrometry.

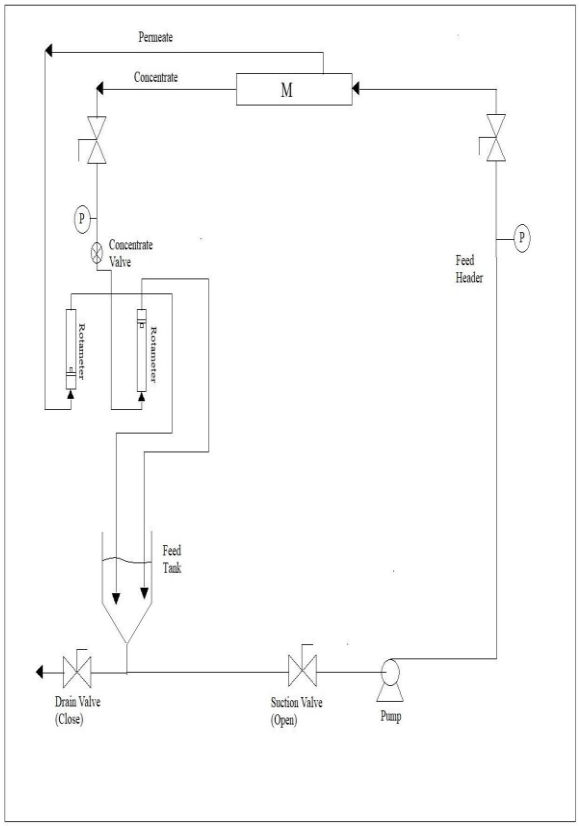


Figure1.Schematic diagram of the pilot plant.

B. Characterisation.

The concentration of metal and metal complexes from permeate and rejection of the membrane unit was tested using AAS(Atomic absorption spectrometry)Chemito AAS,201, Atomic Absorption Spectrometry (AAS) is a technique for measuring quantities of chemical elements present in samples by measuring the absorbed radiation by the chemical elements of interest. This is done by reading the spectra produced when the sample is excited by radiation. The atoms absorb ultraviolet or visible light and make transitions to higher energy levels. It utilises the principle that elements in the gas phase absorb light at very specific wavelengths which gives the technique excellent specificity and detection limits.

III. RESULT AND DISCUSSION.

Figure 2, illustrates the percentage rejectionversus chromium concentration without the addition of water-soluble polymer (PEG).For all flow rate(1.5,2,2.5,&3 L/hm2), percentage rejection of Cr3+ ions increased with increased in Cr3+ion concentration from 50 to 200ppm, without PEG, the percentage rejection of Cr3+ ions increased as per following sequence of flow rate 3>2.5>2>1.5(L/hm2).97.8% rejection of Cr3+obtained at a flow rate of 3 L/HM2, whereas 96.8% rejection obtained at 1.5 L/hm2 flow rate without PEG. It cleared from a result that increased in feed concentration of Cr3+ ion, percentage rejection increased with increased in feed flow rate.Figure3, shown, percentage rejection of Cr3+ ion versus feed concentration at (1.5, 2, 2.5&3L/hm2) flow rate with water-soluble polymer PEG.Comparing the result with and without water-soluble polymer (PEG).it observed that percentage rejection of Cr3+ ion was found to be 99.5%,99.3%,99% & 98.76%at 3,2.5,2 &1.2 flow rate respectively, it showed, percentage rejection Cr3+ ions with addition of water-soluble polymer PEG was found to be almost 4% more than without PEG.it was due to the fact that heavy metals ion Cr3+ formed complex with water-soluble polymer (PEG) in order to increase their molecular weight with size larger than pores of selected membrane that can be retained,[5][1] and thus, increased in feed concentration of heavy metal ion ,it formed more complexes with water-soluble polymer PEG, and resulted in more rejection with addition water-soluble polymer (PEG).

Figure2,Relation between % rejection and Chromium concentration at 1.5,2,2.5 &3 flow rate.

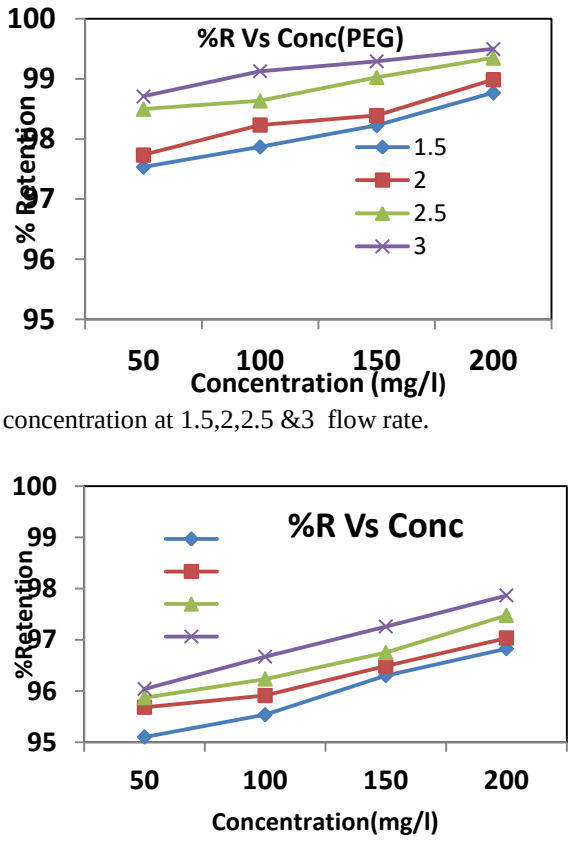


Figure 3.Relation between % rejection and Chromium concentration at 1.5,2,2.5 &3 flow rate with PEG.

Figure 4 ,shown the percentage rejection of heavy metal ions with feed flow rate at various feed concentration heavy metal ions without addition of water-soluble polymer PEG.it was observed that with increased in feed flow rate and concentration, percentage rejection of heavy metals ion increased, At feed flow rate 555,462,370, 277, L/hm2 at 200 ppm concentration, percentage rejection of heavy metal ion was found out to be 97.8,97.2,96.6,96 %respectively. Figure 5, illustrates the percentage rejection of heavy metal ion versus feed flow rate at various concentration with addition of water-soluble polymer PEG, it was found that with the addition of water-soluble polymer PEG, percentage rejection for heavy metal ion was found 3 to 4 per cent more than without the addition of water-soluble polymer PEG,it was due to the fact that water-soluble polymer formed complexes with heavy metal ions, larger the concentration of heavy metal ions, it formed more complex with PEG, and thus, percentage rejection of heavy metals ion was increased with increased concentration and feed flow rate .

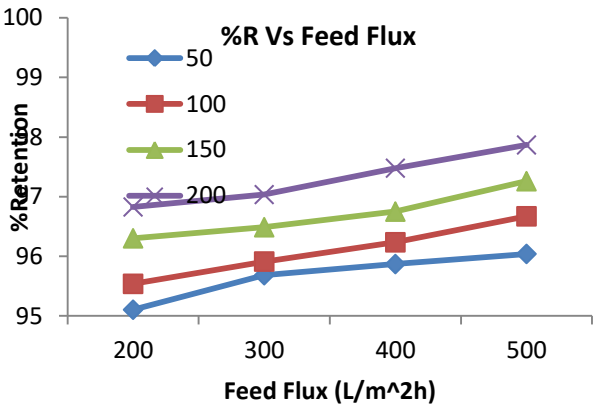


Figure 4.Influence on percentage rejection versus feed flow rate at various concentrations without PEG.

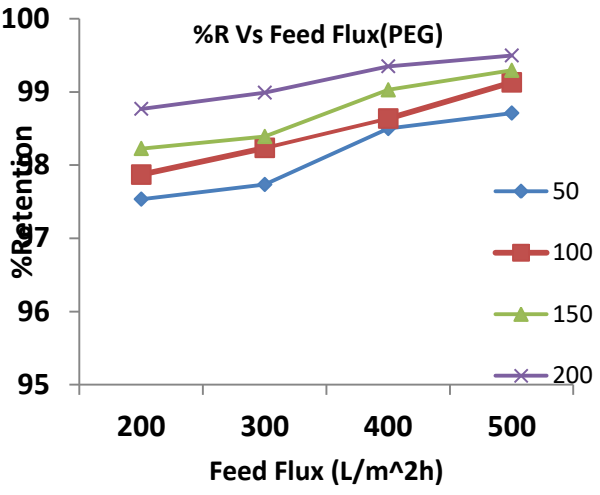
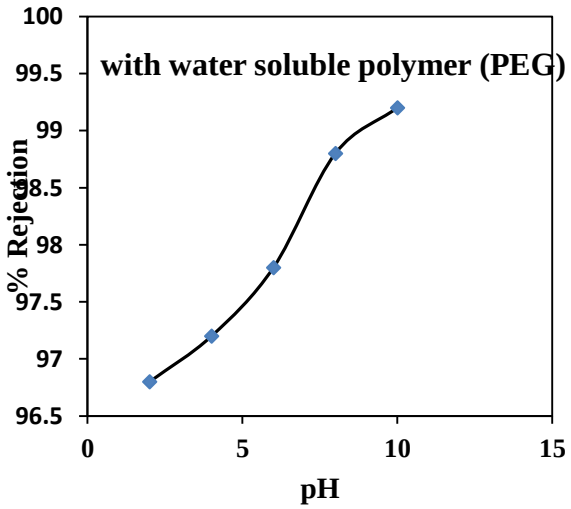


Figure 5. Influence on percentage rejection versus feed flux at various concentration

Figure 4, shown, percentage rejection of heavy metal ion (Cr3+) versus different pH at a constant feed concentration of heavy metals ion (150 PPM) without PEG increased. At 10,8,6,4&2 Ph,percentage rejection of heavy metal ions was found out to be 96.6%,95.8%,94.4%,94% and 93.4% respectively, . It was observed that increased in pH of the feed solution, percentage rejection of heavy metals ion increased, Figure 5, showing the percentage rejection of heavy metals ion with respect to various pH of feed solution at constant feed concentration(150PPM), with the addition of water soluble polymer PEG in the feed solution.it found that percentage rejection of heavy metal ion increased with addition of water-soluble polymer PEG, At pH 2,4,6,8 &10, percentage rejection of heavy metal ion was found out to be 96.8%,97.2,97.8,98.8,99.2 respectively, it was found that with the addition of water-soluble polymer (PEG), percentage rejection of heavy metals ion increased with increased in PH of feed solution at 150ppm concentration. It was due to the fact that metal ion rejection increased with increase in pH value, and reaching 99.2% value at pH 10.it can show that the stability of complex formation is pH dependent. At low pH, affinity of PEG towards metal is weak, due to the presence of positive charges and hence stability is low, As pH increased, affinity and stability towards metal complex formation with PEG increases(MA BARAKAT) and thus addition of PEG(water-soluble polymer) increases ,percentage rejection of heavy metal ions. In previously it resulted that at low pH value, percentage rejection decrease and at low pH values almostno metal ions are complexed. This indicates the possibility of a recovery process for reuse of polymeric agent by readjusting pH.[10]

Figure 6.Influence of pH on %rejection of chromium ion without PEG.



IV. CONCLUSION

The viable technique for Cr (III) metal ion rejection via Nano filtration in combination with water-soluble polymer polyethylene glycol can be applied effectively to Cr3+ ion. PEG as water-soluble polymer showed better performance for separation of heavy metal ion Cr3+compare with without addition PEG.pH, metal concentration and the flow rate was found an effective parameter to control the percentage rejection of heavy metal ionCr3+. At pH 10, andat 200ppm concentration, andat 3(L/hm2) flow rate found highest percentage rejection of heavy metal ion Cr3+. The result indicates that with the addition of PEG gave higher rejection of heavy metal ion.

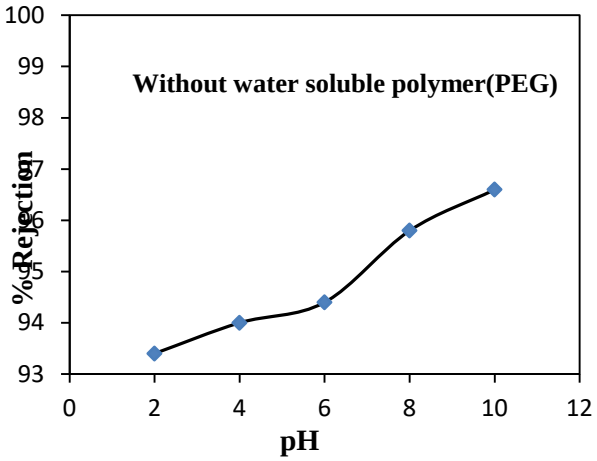


Figure 7.Influence of pH on %rejection of chromium ion with PEG.

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PhD area-Membrane casting, characterization and its application for separations

Patents.

1] Patent 1-
Title of the invention- Portable three layer water purification bottle
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2] Patent-2
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Research Publications in Journals: International Journals : 10

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