RESIN INDUSTRY EFFLUENT TREATMENT THROUGH HYBRID REVERSE OSMOSIS SYSTEM

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ABSTRACT

Phenol and organic compounds are among the foremost prevailing types of organic chemical pollutants in resin industrial wastewaters. Therefore, treatment of these wastewaters is needed before final discharge to the environment. Among the various processes delineate for removal or degradation of synthetic resin compounds, hybrid processes that mix pressure driven membrane processes with sorption processes are developed. So as to optimize those phenol concentrations, an in depth study of the effectiveness of the resin bed and membrane method step is important. A study of phenol, BOD, COD, TDS removal from binary compound solutions by hybrid reverse diffusion mistreatment totally different experimental conditions (feed phenol concentration, amount of XAD-4 resin, pressure and pH) and totally different R.O. membranes (polysulfonate, synthetic resin, cellulose ester, nitro polyose, polyacrilonitrile, polyamide, PTFE, PVF) is dispensed during this paper. The water and phenol removal potency are obtained consequently to the treatment for maintaining ZLD (Zero Liquid Discharge).

Key words: *Phenol, Wastewater, Adsorption, XAD-4 resin, Oxidation, Reverse osmosis, Membrane Process.*

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1) INTRODUCTION

A research conducted in USA concerning the presence of organic contaminants in streams shows that eightieth of these streams contained organic contaminants. Phenol and phenol compounds area unit among the foremost current sorts of organic chemical pollutants in industrial wastewaters. Industrial processes like oil refineries, organic compound plants, ceramic plants, steel plants, coal conversion, organic compound trade plant (Phenol gas Resin), and pharmaceutical industries, generate liquid effluents containing high concentrations of phenol and different compounds. Phenol is potential human matter and is of right smart health concern, even at low concentration [1]. Acute poisoning will cause severe duct disturbances, excretory organ malfunction, cardiovascular system failure, respiratory organ dropsy and convulsions fatal doses will be absorbed through the skin. Key organs broken by chronic phenol exposure embrace spleen, duct gland and kidneys [1]. Careful treatment of effluent containing phenol and phenol compounds is then needed before final discharge to the surroundings. Several technologies are investigated for removing and degradation of phenol compounds in effluent. They enclosed surface assimilation [2], protein treatments [3], and reaction [4] and combined techniques [5].

Many studies are performed on the separation of organics and organic pollutants by artificial membranes, and these studies have known a number of the distinctive aspects related to organic separation. In an earlier research analysis they need compiled separation and flux data of cellulose acetate membranes for large range of organic compounds, as well as several organic pollutants. They found that organic separation can vary wide (from <0% to 100%) counting on the characteristics of the organic (polarity, size, charge, etc.) and in operation conditions (such as feed pH, in operation pressure, etc.). Rejections varied significantly for the various solutes, and rejections of ionizable organics were greatly dependent on degree of dissociation; non-ionized and hydrophobic solutes were found to be powerfully absorbable by the membranes and exhibited poor rejection.

Many strategies, like oxidization, precipitation, adsorption, ion exchange, natural process and solvent extraction are accustomed to take away phenol materials from liquid solutions. The RO separation of AN organic substance from liquid solutions is of interest from the point of view of its application for wastewater treatment and pollution management [3]. Membrane processes are often accustomed to remove phenol from water; however they were not perpetually successful [4]. Therefore, increasing attention is being paid to the study of assorted chemical and physical processes to accompany such separation systems. In general, depth filters, GAC, microfiltration and ultra-filtration are accustomed to reduce the pollution loading for RO systems. If the potential of a RO membrane module for phenol removal is to be investigated, such pre-treatment strategies should be thought of. Thus, the target of the subsequent study is to research phenol removal by two pretreatment strategies and RO below completely different conditions.

2) MATERIALS AND METHODS

2.1 Experimental set-up of Resin bed Reactor

The experiments were conducted on pilot-scale equipment (Figure 1). XAD-4, a nonionic chemical polymeric compound resin composed of polystyrene chains cross- connected with divinylbenzene, was used as the adsorbent for learning the surface assimilation behavior of varied Phenols contain industrial waste water [16]. The medium size of the resin is 35‑40 mesh or 0.02 inch. The specific extent, average pore volume, and average pore determined to be $820m^3/g$, $0.81cm^2/g$, and 23.8 Å, respectively.

For the adsorption equilibrium experiments, planned amounts of XAD-4 resin were introduced into resin bed reactors filled with resin balls of notable concentrations of phenol and also the whole reaction setups were maintained at 30±5◦C. The solution pH was adjusted to desired level (between 3 and 11) by adding acidic or alkaline solutions to the Collection tank. The waste water distribution continues on the resin balls. After 40-50 minutes of contact time for resin balls and phenol-containing waste water, the solution pH was recorded and also the resin balls was allowed to pass remaining water from the percolated receptacle. The mesh size of that receptacle is a smaller amount than 0.02 inch. The solution pH was recorded, and also the concentrations of varied phenols within the filtered samples were determined by measuring the absorption of specific wavelength with a UV-160A UV/visible spectrophotometer. Experiment was performed for different resin balls quantity and found the best efficiency of waste water recovery.

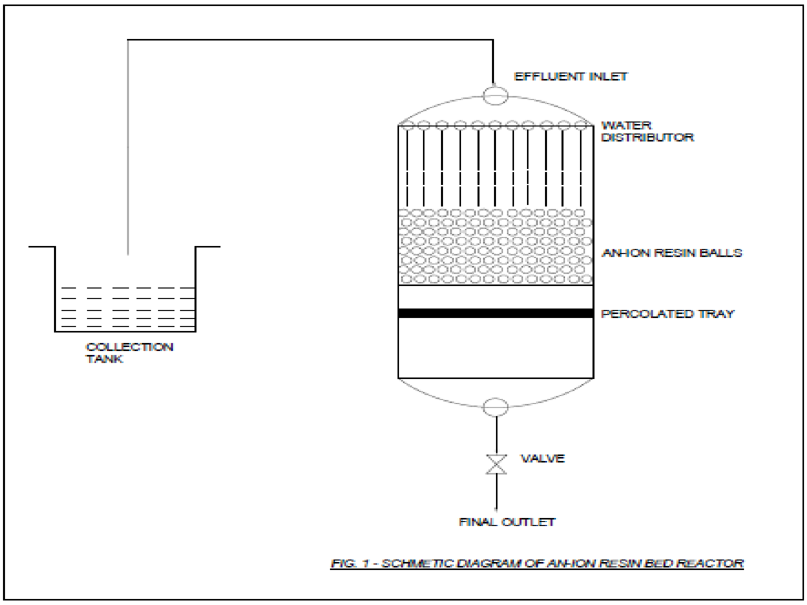

Figure: 1- Schematic Diagram of Non-Ion Resin Bad Reactor

2.2 Regenerating an ion-Exchange Resin

As expressed earlier, an ion-exchange organic compound in industrial use is sometimes regenerated each 12 to 48 hours. Looking on the use of the resin, this can be tried in many alternative ways, every with their own benefits and drawbacks looking on each chemical and economic factors [9].

Regeneration is very important because reducing the regenerate level lowers water quality by permitting a little proportion of the ions that area unit being obsessed by the resin to slide through without exchange. As for example, with twin bed deionizers, incomplete regeneration of the cat-ion resin to the hydrogen form permits leak of some Na (the least held of the cat-ions ordinarily found in natural supplies) into water passing to the anion exchange vessel [6]. Consequently, the water leaving the anion unit still contains this sodium within the sort of hydroxide solutions usually of pH 8 to 9. However, the excessive amounts of regenerate needed for complete regeneration implies that this is often seldom sensible. In practice a compromise is usually reached, and ordinarily resins area unit regenerated to about 2 thirds of the whole capability. Additionally, for several uses total purification isn't necessary. As an example, the water with a pH of 8 to 9 mentioned earlier is extremely appropriate to be used in boilers, as they need slightly alkaline water.

Some impurities like silicon dioxide will solely be removed by a powerfully basic Resin. As an example, dissolved silicon dioxide could be a major element of most water supplies. Usually it exists as a neutral polymer, and it becomes negatively charged solely at high pH levels. This implies that it will solely be off from water within the extremely alkaline environment of a powerful base resin in the hydroxyl form.

The exchange method is commonly made more efficient by introducing the regenerant at rock bottom of the resin column and passing it upwards through the bed (counter current regeneration). This ensures that the resin at rock bottom becomes a lot more extremely regenerated than that above it. Treated water leaving the column flowing downwards then comes up in contact with this resin last and undergoes the highest possible degree of exchange.

2.3 Pros and Cons in the use of Ion-Exchange Resins

The advantages of ion exchange processes are the very low running costs. Very little energy is required, the regenerant chemicals are cheap and if well maintained resin beds can last for many years before replacement is needed. There are, however, a number of limitations which must be taken into account very carefully during the design stages. When these limitations itemized appear to represent a formidable list and the impression can be given that ion exchange methods might have too many short comings to useful in practice. However, this is not the case as the advantages mentioned above are very great and compensation can readily be made for most restrictions. [7]

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2.4 Experimentation with hybrid R.O. System

The whole experiment performed on Laboratory base. The resin industry waste water containing different characteristics i.e. pH, Phenol, COD, BOD, TDS, TSS. Treatment of that waste water is very important. Predetermined amount of waste water and resin has been taken. The development for phenol removal techniques administrated with XAD-4 resin, carbon filter used for the colour removal with BOD and COD removal of minimum proportion. For the high range of BOD and COD, secondary treatment is important with high pressure aeration system (pressure=2 atm).After the aeration system the effluent ought to be introducing onto U.F. Membrane for TSS removal. The RO system was assumed for high range of TDS Removal. Throughout 60 seconds at the start of experimental studies. Then the experimental was operated ordinarily. The flows were regulated and also the concentrate stream was recycled to the feed tank. The Permeates from the RO were collected in another tank and also the parameters were measured. The RO rejected were use in gardening purpose or it ought to be evaporated based on its characteristics. After every experiment, the RO membrane was washed with distilled water. The pH and conductivity of all samples were measured. The Hybrid R.O system experimental result shown in Table: 2.

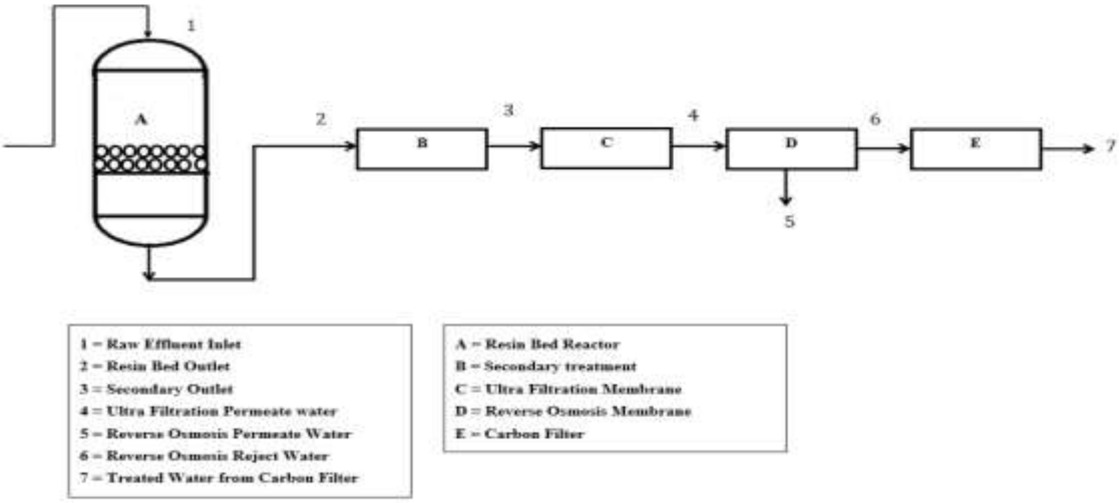


Figure: 2- Schematic Diagram of Hybrid R.O.System

3) RESULTS AND DISCUSSION

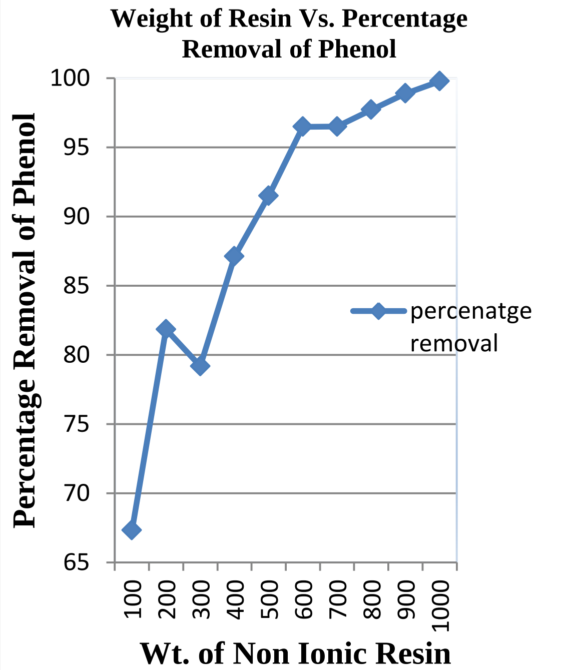
3.1 Effect of initial concentration

The effect of the initial phenol concentration on the removal efficiency is plotted in Fig. 1. During this study phenol concentration was varied between 1 to 107 mg/ L and also the resins dosages were kept at 100 gm/L to 1000gm/L. Results show that phenol ions removal through resins is significantly influenced by its concentration within the feed stream. It had been found that the phenol removal from 107 mg/L (Initial) from 1-3 mg/L phenol within the outlet stream, to 99.7 % for the highest assayed concentration under identical XAD-4 operational conditions in terms of recirculation time and temperature for the robust non -ion exchange resin. In this case, it can be ensured that XAD-4 was the predominant method accountable of the phenols ion removal since the rise in resin amount within the outlet stream was directly proportional to the removal efficiency for every assayed initial concentration. Hence, the decrease within the removal percentage with the phenol concentration within the feed stream can be associated with saturation of the XAD-4 resin. The experiment result shown in Table: 1.

Table 1: Result of Experiment on Resin Bed Reactor

Sr. No.	Weight of Non-Ion Resin taken (gm)	Initial Phenol Concentration (mg/L)	Final Phenol Concentration (mg/L)	Percentage Removal (%)
1	100	90	25.20	67.32
2	200	107	23.50	81.85
3	300	97	18.36	79.19
4	400	99	11.99	87.12
5	500	101	9.40	91.50
6	600	102	5.40	96.49
7	700	98	1.53	96.50
8	800	99	1.28	97.72
9	900	100	1.10	98.90
10	1000	101	1.20	99.78

Figure 3 shows the removal of phenol over a pH scale vary of 4-9 by Ro within the presence of pre-treatment, so showing the phenol removal capability of the resin worse. Phenol removal will increase with AN increasing amount of resin balls, particularly when it was above 700 gm to 1000 gm. Increasing in phenol removal was very near. The variation in pH scale from 4 to 6 increases the removal efficiency slightly, i.e. from 67% to 87%, however it fell dramatically to 99% at pH scale 6.5. It was absolutely found that the most effective removal by XAD-4 resin alone occurred within the range of pH scale 4-7.



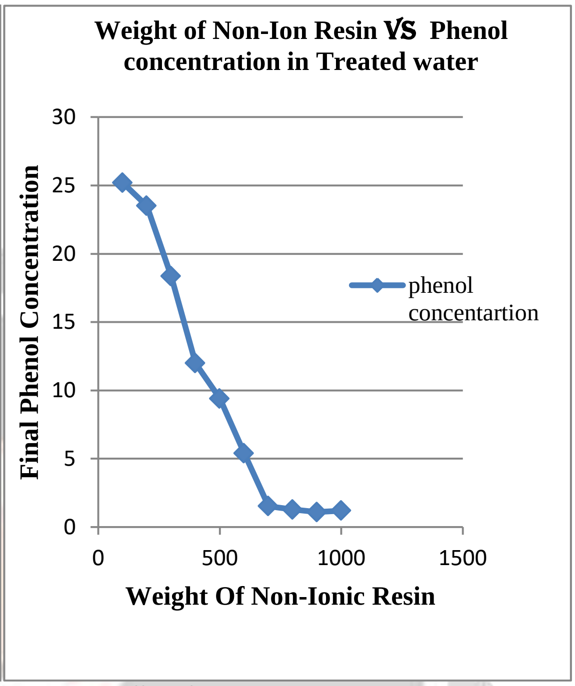


Figure: 3: Effect of Weight of Resin balls to Phenol Removal Figure: 4: Effect of Non-Ionic Resin to Phenol Concentration

The phenol concentration in the influent was kept at 107 mg/l. After the application of XAD-4 resin, the phenol concentrations in the effluent varied from 107 mg/l to 1 mg/l, depending on the pH. When the pre-treatment methods, i.e. the XAD-4 Resin bad, are incorporated, the overall efficiency of the RO increases. The variation of phenol rejection with feed concentration, pressure and pH for the three membranes is represented. Poor rejections are obtained in all cases, with polyamide membranes showing better results. It has been suggested that for the removal of high value of BOD and COD the secondary treatment is required before treating effluent in the R.O. Pressure increase leads to a significant decrease of BOD and COD rejection. There are some factors related to the molecular characteristics of organic molecules (solubility, acidity, ability to hydrogen bonding, etc.) that affect their rejection by reverse osmosis membranes. Those factors favor organic solutes like phenol to be sorbed into the membranes and to be more easily transported across them, leading to low rejection values. The consistency for removal of TDS and TSS, the U.F. Membrane was installed and finally the remaining characteristic water treated by R.O. membrane and got effective result. (As per State pollution control board).

Table 2: Result of Experiment on Hybrid R.O.System

Sr. No.	Stream No.	1	2	3	4	5	6	7
	Parameter (mg/L)	Raw Effluent	Resin Bed Outlet	Secondary Outlet	U.F. Permeate	R.O. Permeate	R.O. Reject	Carbon Filter Outlet
1	pH	6.2	6.4	6.4	7.1	7.0	6.5	6.9
2	Phenol	102	1.2	NIL	NIL	NIL	NIL	NIL
3	COD	129600	58320	1166	315	95	150	70
4	BOD	32100	18900	380	95	24	41	30
5	TSS	130	130	110	90	9	2	1
6	TDS	8600	8600	8600	7740	1700	4000	2040

5. Conclusion

Hybrid processes have been developed for treatment of waste water of resin industry combining adsorption and RO. Experiments has been conducted with Non-Ionic Resin bed reactor for phenol removal. The high quantity of resin balls removes high amount of phenol. At 700 gm optimum removal of phenol was achieved. No significant removal after that was noted. Adsorption with XAD-4 resin has given 99.7% removal of phenol from waste water with the help of weight of resin balls. In order to optimize, the concentration of phenol, TDS, BOD and COD hybrid processes were determined, a detailed study of the effectiveness of the membrane process step is necessary. A study of phenol removal from aqueous solutions by reverse osmosis using different experimental conditions (feed phenol concentration, pressure and pH) and different membranes has been carried out in this paper. Good rejections are obtained in all cases, with polyamide and cellulose acetate membranes showing better results. Some factors related to molecular characteristics of phenol, such as solubility, pH, BOD, COD rejection were determined. Good significant differences have been found on phenol rejection coefficients at different feed phenol concentrations and feed pH. Finally, phenol removals with its related characteristics were within the limit of state pollution control board norms.

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