EFFECT OF CONTACT TIME ON ADSORPTION OF NITRATES AND PHOSPHATES

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ABSTRACT

Water pollution due to the excessive presence of nutrients (nitrogen and phosphorus) is a serious environmental worldwide problem, because both species are responsible for the eutrophication of receiving surface waters and elevated nitrate concentration in drinking water can be toxic to infants. Hence it is very necessary to remove these nutrients from the effluent stream. The study presented in this paper describes the adsorption capacity of an anion exchange resin Auchlite A101D for the removal of Nitrates and Phosphates from an aqueous solution. A series of batch experiments were carried out to determine the adsorption capacity of resin by varying the contact time. The tests were carried out on synthetic samples. Maximum adsorption capacity of the resin in case of Nitrates was 68.08 mg/gm and that for Phosphate was 50.8 mg/gm.

***Keywords*–Auchlite A101 D, Adsorption Capacity, Nitrates, Phosphates, UV Sprectophotometer**

I. INTRODUCTION

Although Nitrogen and phosphorous being essential elements for living organisms, their enormous volume of wastewater production containing nitrate and phosphate leads to the deterioration of natural water resources through eutrophication. The need to develop new technology for phosphate and nitrate removal from wastewater has become very important to conserve natural aquatic environment from eutrophication. The primary health hazards from drinking water with nitrate occurs when nitrate is transformed to nitrite in the digestive system which creates the condition known as methemoglobinemia which commonly observed among children [1]. According to environmental protection agency (EPA), the drinking water limit of nitrate is 45 mg/L [2] and the maximum permissible level of phosphates in water is 0.1 mg/L [3].

Nitrate is a common pollutant of groundwater in many regions around the world. Chemical fertilizer used in crop production and municipal or industrial wastewaters are characterized as the extensive source of nitrate in watersources[4].

Phosphate is a non-renewable major nutrient that is used in fertilizers throughout the world. Phosphate rock mining depletes analready dwindling supply of phosphate where a majority ends up in our food and is excreted as urine. Urine goes to wastewater treatment plants where it is diluted approximately 100 times with other wastewater streams. Wastewater including urine is treated to remove biodegradable organic material and to a lesser extent nutrients [5].

Nitrate and Phosphates removal can be carried out by adsorption, ion exchange, electrodialysis, reverse osmosis, microbiological treatment (denitrification), chemical treatment (coagulation), etc. Amongst them, adsorption is simpler and effective for nitrate removal. Adsorbent resins are considered to be highly stable and hence considered as one of most promising adsorbents. Resins are the polymer matrix structures having ions and a functional group along with alkyl chain present in it. Ion exchange resin has the characteristic of replacing ion with other substitute present in the aqueous solution [6]. Also the regeneration capacities of an Ion exchange resin makes them cost effective.

II. EXPERIMENTAL

2.1 Materials

A strong base anion exchange resin AuchliteA 101 D was acquired from Auchtel Products Ltd. It is Benzene Diethenyl, polymer with Ethenylethyl benzene, trimethyl amine with Chlorides as the exchangbleions.Its important charecteristics such as resin matrix, ionic form, specific gravity, effective size, uniformity coefficient, particle size are presented in Table1. The stock solution of Nitrate and Phosphates used in this study was prepared by adding an accurate quantity of Sodium Nitrate and Potassium Dihydrogen phosphate in Deionised water respectively. The required concentration of Nitrate and Phosphate solution was prepared from this stock solution. For batch study, mechanical shaker was used to vibrate the samples at 120 rpm. Determination of Nitrates and Phosphates was done by UV Spectrophotometer (HACH DR 2400).

Table 1: Characteristics of Auchlite A 101 D

Resin Matrix	Cross linkedPolysterene
Ionic Form	Chloride
T.E.C. meq/ml in Cl Form	1.33
Specific Gravity	1.1
Effective size(mm)	0.49
Uniformity coefficient	1.56
Particle size(mm)	0.3-1.2
Operational pH range	0-14

2.2 Batch experiment

Batch experiment was carried out to investigate the effect of contact time on the removal of Nitrates and Phosphate.The study was conducted at room temperature to be representative of environmentally relevant condition. The glass flasks were used in the study. The flasks were shaken at constant rate, allowing sufficient time for adsorption equilibrium. Mechanical shaker was used to vibrate the glass flask containing sample.It was assumed that the applied shaking speed allows all the surface area to come in contact with Nitrates and Phosphates over the course of the experiments.

The fundamental equation which is used in the adsorption studies is given below.

The adsorption capacity q_t(mg/g) of resin at time t can be estimated as follows

$$q_t = \frac{(Ci - Ct)v}{m}$$

Where,

q_t adsorption capacity of resin in mg/g at time t

C_i is the initial nitrate (or phosphate) concentration in mg/lit at the start of the experiment

C_t is concentration at any time t of the nitrate (or phosphate) is a solution in mg/lit

v is the volume of nitrate (or phosphate)solution and

m is the mass (mg) of resin.

III. RESULTS AND DISCUSSION

3.1 effect of contact time on removal of Nitrate

The experimental data were measured at 3 h to make sure that full equilibrium was attained. The initial Nitrate concentration was kept constant i.e. 100 mg/lit and a constant adsorbent dose of 1 gm/lit was applied. The samples were contacted using a mechanical shaker at a constant speed of 120 rpm. The Nitrateconcentration was measured at an interval of 20 min using a UV spectrophotometer. The observations are presented in Figure 1.

Adsorption rate initially increased rapidly, and the optimal removal efficiency was reached within about 100 min. Further increase in contact time did not show significant change in equilibrium concentration; that is, the adsorption phase reached equilibrium.

Fig 2 depicts the Adsorption capacity (in mg/gm) versus contact time. It is observed that maximum adsorption capacity of 68.08mg/gm was obtained at 3 hrs contact time and at equilibrium time of 100 minutes, adsorption capacity of 58.714 mg/gm was achieved. It is clear from the above graph that once the equilibrium is reached, further increase in contact time does not have significant effect on nitrate removal.

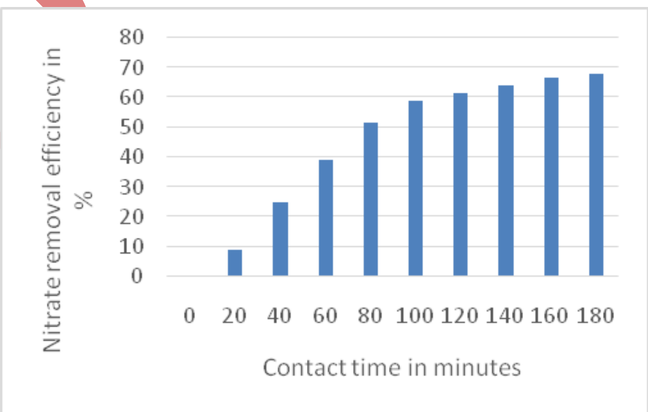

Fig 1: Nitrate removal efficiencies vs. contact time

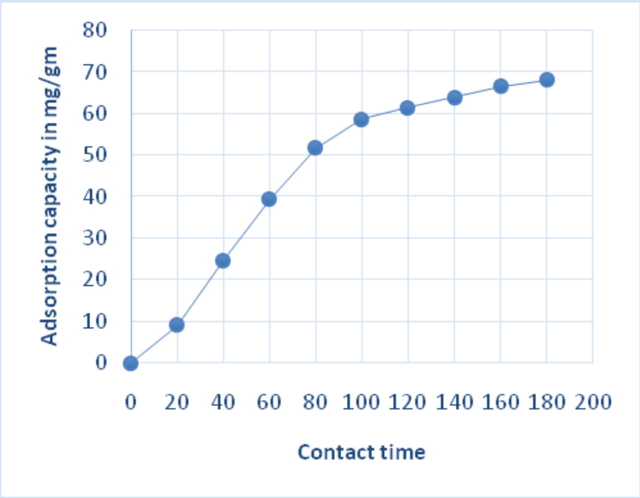

Fig 2: Adsorption capacity vs. contact time

3.2 effect of contact time on removal of Phosphate

The similar experiment was carried out under similar experimental conditions on the aqueous sample containing 100 mg/lit of phosphates. The results are presented in fig 3

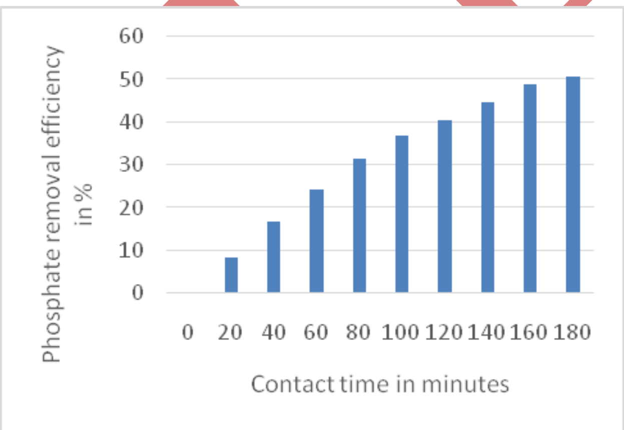

Fig 3:Phosphate removal efficiencies vs. contact time

In case of phosphate it was observed that, phosphate removal went on increasing initially for the first several minutes and later the removal became somewhat stable as can be observed in fig 2. Equilibrium is reached after 140 minutes.

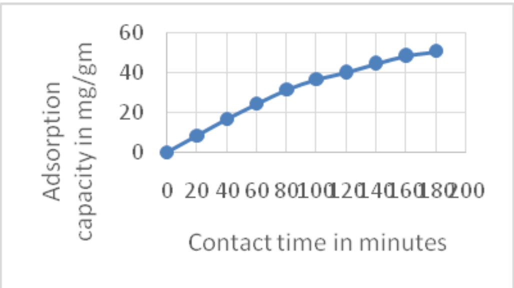

Fig 4: Adsorption capacity vs. Contact time

Adsorption capacity at the end of 3 Hr. contact time was 50.8 mg/gm and at the end of 140 minutes it was 44.8 mg/gm.

3.3 Comparative study with Nitrates and Phosphates

Since the batch study was conducted independently on the aqueous sample containing nitrates and phosphates, an attempt was made to compare the removal effectiveness of an Ion exchange resin Auchlite A101D to remove nitrates and Phosphates. Figure 5 shows the comparisons made in this study.

Figure 5 represents the final nitrate and phosphate concentration in an aqueous solution at the respective contact time. It was found that final nitrate concentration in the solution at any contact time is comparatively lower than the Phosphate. This indicates that the uptake of Nitrate on an ion exchange resin Auchlite A101D is comparatively faster than that of Phosphate

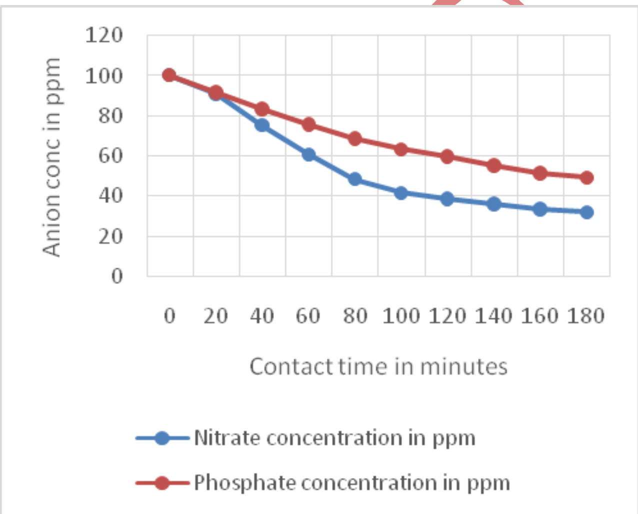

Fig 5: Comparison of Nitrate and Phosphate removal

IV. CONCLUSION

Results from this study revealed that initially the percentremoval increase, rapidly with the increase in contact time; however, after some times the rate becomes almost constant. This is because all the available active centers on the adsorbent have been occupied and there are no further sites and hence no further adsorption is possible. Nitrate attains equilibrium at about 100 minutes while the equilibrium time for phosphate adsorption is found to be around 140 minutes. The study also concluded that, the ion exchange resin Auchlite A101D has more affinity towards Nitrates than that of Phosphates.

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