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Research article

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Removal of erythromycin from simulated effluents

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Abstract

With demand prevailing towards a better cure, people have started to rely on the drugs in various formulations for a better and faster cure. As demanded by the society, industries came up with products and services which fulfilled the need. With many drugs reaching the market, people with huge choices for their cure started using such products and the after effect of the drugs and their exposure became immeasurable. The effect of drug use by people towards the environment is worse. In a view to protect the environment, many measures have been taken to safeguard the people and the society. Many conventional methods are available for effluent treatment, such as adsorption, remediation, purification, etc. This study principally involves the use of sorbents for the removal of erythromycin from water. The results were supporting and have shown a better adsorption rate at pH 5 with drug and adsorbent concentration being 1%.

Keywords

Effluent treatment; Erythromycin removal; Simulated effluent; Adsorption; Sorbents

Introduction

A need for a cure is always is in demand. This demand gave rise to the manufacture of drugs. Drugs are defined as the molecules that cure a disease or an ailment with defined dosage.[1] Drugs produced and manufactured are of different classes, such as anti-inflammatory, antipyretics, antiviral, antibiotics, etc. Each drug has its own characteristic role and functional behaviour against a particular disease or ailment. Among the drugs, antibiotics are a class of molecules or drugs that are taken to treat the bacterial infections or bacterial inhibitors. As more beneficial research outcomes became evident with the predominant use of antibiotics, people started becoming dependent on these antibiotics.

Antibiotics are of various classes and are commonly used to treat bacterial infections, such as cough, pneumonia, diphtheria, etc.[1] Erythromycin is one among the antibiotics that is widely used to treat infections caused by Gram-positive bacteria, and its effects on the nature as a result of its degradation inability are also widespread.[2] Pharmaceuticals like this are available in the environment either as an unused drug or as used drug or as a metabolised end product or as a trace element in the water bodies. A study reports that 15% of drug taken is said to exist in the faeces of human beings who consume erythromycin.[3] When the metabolic waste reaches the surface ecosystem by natural process such as excretion, it ultimately tends to disturb the water ecosystem by improper sewage treatment or improper disposal of unused drugs.[4] Also, the traces of antibiotics found in the drinking water have led to the development of antibiotic-resistant organisms at various levels as a result of their exposure in the environment.[5] Researchers' interest has turned towards this broad spectrum field where demand prevails to ensure environmental safety. The surface ecosystem imbalance in the last level disturbs or brings about some unusual harmfulness to water intake by the mixing of sewage effluents into water streams or bodies. Recent study proves that minute quantities of pharmaceutical waste are found in the water bodies either by direct or indirect disposal of pharmaceutical effluents.[6] The question aroused among the researchers few years back was whether there is any solution to evade its toxicity or its treatment in the effluents.[7] With increasing demand or need to find a solution for this, people, researchers, governmental and many non-governmental organisations have put forth many ideas and proposals to subsidise the effects of pharmaceutical effluents in the water bodies and their environment.[8] Many methods, such as adsorption, removal, oxidation and treatment were adopted for treating pharmaceutical effluents from the environment.[9] Erythromycin was highlighted as one of the three pharmaceuticals designated as priority drinking water contaminant by US EPA report CCL-3 from September 2009. This was based on the occurrence of erythromycin in environmental waters and its health effects.[10] Erythromycin is a persistent water pollutant that is not degraded or removed by conventional waste water treatment.[9] In drinking water treatment, 75% of erythromycin concentration can be reduced by using disinfectant method.[11]

With the availability of many methods and techniques in the removal or treatment of these pharmaceutical effluents, each of them has its own uniqueness in operation, advantages and disadvantages. To point it out in few words, adsorption of pharmaceutical is one such technique that is performed or aided as physical, chemical, biological, etc. This study principally involves the adsorption of simulated effluent with sorbents.

Materials:

The chemicals and reagents used in the study were obtained from Hi-media and Merck Chemicals, India.

Methods:

Standardisation of erythromycin estolate

Simulated effluent was prepared by taking 8 ml of erythromycin estolate and it was made up to 20 ml using distilled water and ethanol in the ratio 1:1. Further dilutions were made according the method given by Sayed RA et al.[12] with ethanol, and the standard table for erythromycin was made.

Effect of concentration of sorbent used

Throughout the study, the simulated effluents were used and various sorbents were screened for their adsorption ability against them. 50 ml of effluent was prepared with the concentration of 1 mg/ml. Initially, 1% of each sorbent material (activated charcoal, alum, alumina, silica gel) was added to the effluent in a beaker and kept in an orbital shaker for 24 hours.[13,14] After incubation, the spectrophotometric estimation at 485 nm[12] was performed and tabulated.

Effect of acidic pH on sorbent used

The pH of the simulated effluent was altered to 3, 4, 5, 6 and 7 in considering the pK_a value of the simulated effluent. 1% sorbent material was added to the effluent and incubated at room temperature in an orbital shaker. After incubation, the spectrophotometric estimation was performed and tabulated.

Results and Discussions

Standardisation of erythromycin estolate

A standard graph was plotted using different concentrations of the drug and their corresponding absorbance at 485 nm.

The straight line graph obtained is depicted in Figure 1, which points out that the absorbance values are directly proportional to the drug concentration. Thus, increase in drug concentration yielded a higher absorbance value.

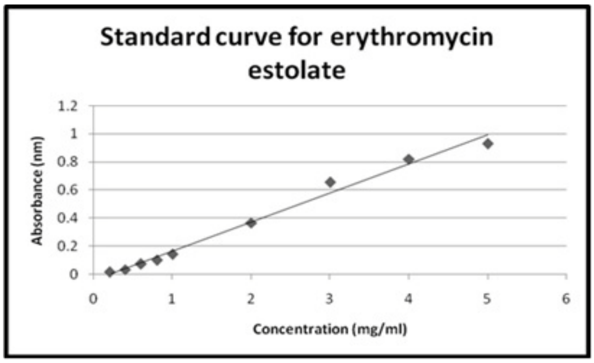

Fig. 1. Standard graph of erythromycin estolate

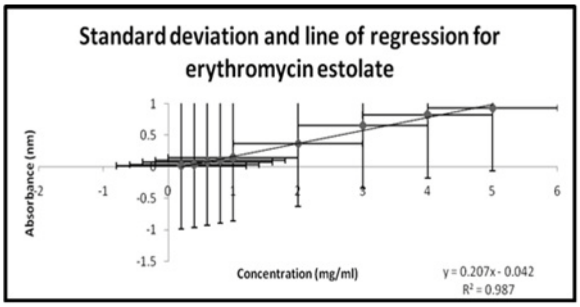

Fig. 2. Standard deviation and regression line of erythromycin estolate standard

Efficiency of sorbent materials

An effective sorbent was determined by studying the efficiency of four materials namely activated carbon, alum, alumina and silica. 1% concentration of each of these materials was tested against the pharmaceutical effluent. Out of these, activated charcoal had the highest percentage of absorbance, approximately 48%. Silica and alum had nearly 25 and 20 adsorbance percentages, respectively. The least value was obtained for alumina having almost 10%.

This data is in accordance to Mahammad-Khan et al.[15] where they state that activated carbon is a better adsorbent than silica gel, activated alumina, zeolites and molecular sieves for the removal of pollutants (such as organic, inorganic and biological) from the water bodies. Its activity is better than other adsorbents because of its much better surface area.[16] Because of its wider surface area, it is able to accommodate much more substances and adsorb an opponent molecule rapidly. Pore size distribution properties are the key indicators of a carbon's potential performance for removing contaminants (adsorbates) from water.[17] Hence, activated charcoal was selected to determine the effect of sorbent concentration and the effect of pH.

The adsorption isotherm of the adsorbent used is according to the following equation[18]:

$$\Theta = KP/(1+KP)$$

Where,

ϴ = the number of sites of the surface which are covered with gaseous molecule

P = pressure

K = the equilibrium constant for distribution of adsorbate between the surface and the gas phase

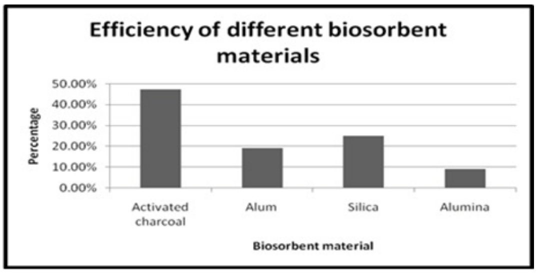

Fig. 3. Efficiency of different sorbents at 1% concentration

Effect of sorbent concentration

Different concentrations of activated charcoal were taken to check their influence in adsorption. Upto 1.5% of charcoal, a steady increase in the adsorption percentage was noted from 10% to 50%. However, at 2.5% concentration, the absorbance value drops to 40%. According to Alotaibi et al.[19], the rate of adsorption is dependent on charcoal to drug ratio. The same trend was reported by Qadeer et al.[20] wherein the adsorption of phenol was gradually rising with increasing concentrations of activated charcoal. However, when phenol concentration was increased to more than 0.3 g/l, the adsorption rate started declining as a result of the interaction of less favourable sites.

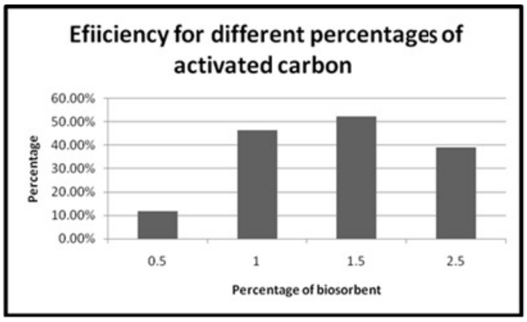

Fig. 4. Effect of different percentages of activated carbon

A similar result was obtained with the removal of erythromycin using activated charcoal where the adsorption rate of activated charcoal started to decrease with the increase in the concentration of the drug. Considering the drug to sorbents ratio, the concentration of both the drug and adsorbent was taken equally to aid a better removal of erythromycin from water.

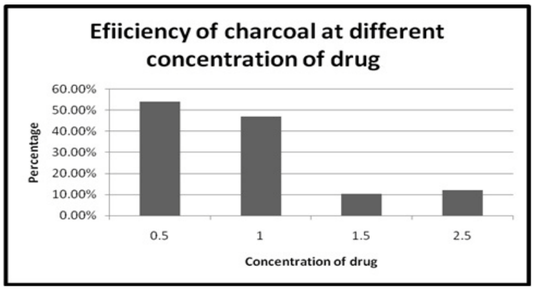

Fig. 5. Effect of different concentrations of sorbent

The pH was chosen based on the dissociation constant of the effluent. With increase in pH of the effluent, an increase in the absorbance was prominent till pH 5. After which, further increase in pH led to a gradual decrease in the activity of charcoal.

The reduced adsorption of erythromycin at neutral pH is attributed to two factors, one is the pK_a value and the other is the charge on the outer surface of the adsorbent. The pK_a value of erythromycin is 6.9. This indicates that a larger amount of adsorbent is required to effectively adsorb erythromycin at neutral pH. Similar data was reported by Ferreira et al.[21] for the adsorption of paracetamol with activated carbon. At pH 11, the adsorption rate had fallen in comparison to pH 2 and 6.5. Paracetamol (pK_a 9) at pH 11 was repelled by the negatively charged activated charcoal. In contrast, at pH 2 and 6.5, the neutral paracetamol was easily adsorbed by the neutral and positively charged adsorbent. With the pK_a value of erythromycin being 6.9, the activity of charcoal was found to be the maximum at pH 5.

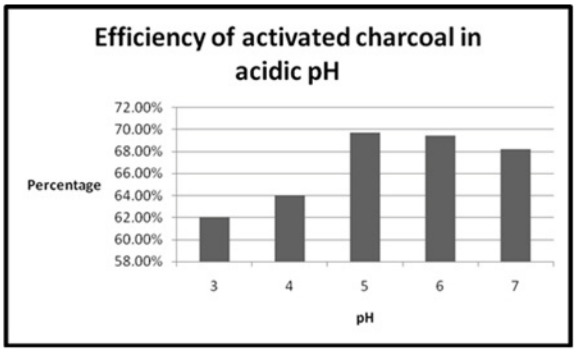

Fig. 6. Effect of pH on activated charcoal activity

Conclusion

To reduce to adverse effects of erythromycin estolate, effective removal mechanism is now of prime importance. Using adsorbents is one such technique for efficient removal of pharmaceutical wastes.

From this study, we conclude that the activated charcoal in comparison to alum, alumina and silica had better activity against pharmaceutical effluent for erythromycin estolate adsorption. Moreover, activated charcoal had a higher absorbance at a concentration of 1% and pH 5. Activated carbon can thus be used as a potential pharmaceutical water treatment technique.

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