Extraction of paracetamol and amoxicillin from synthetic solution using activated carbon

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Abstract. The traces of pharmaceutical products present as emerging contaminants in water bodies needs to be extracted since it causes risk to human health and environment, also as these cannot be removed by conventional water treatment processes. The occurrence and fate of pharmaceutical parameters in water bodies in Indian scenario were studied, from which two pharmaceutical parameters, paracetamol and amoxicillin were selected. This paper primarily focuses on the extraction of paracetamol and amoxicillin from its synthetic sample solutions prepared using Activated carbon as the adsorbent. The analysis is done using UV-vis Spectrophotometry and with solutions of different concentration, pH and adsorbent dosages, removal efficiency is calculated in each case. With the optimized pH and concentration of solution, the optimum dosage of activated carbon is determined by comparing its removal efficiencies.

1. Introduction
The occurrence and fate of pharmaceuticals in water bodies has to be studied to reveal the problems or hazards caused in the environment due to these emerging contaminants[1]. India being the leading country of pharmaceutical production and consumption, study on pharmaceutical and personal care products (PPCPs) are significant. Despite of these high production and consumption rates, research on occurrence, transport, fate and removal of PPCPs from waste water is in budding stage[2]. Pharmaceuticals and personal care products (PPCPs) include active ingredients of prescription and non-prescription drugs for human and veterinary use, disinfectants, illicit drugs, body lotions, etc.[3].

PPCPs after its biological response from host, it is ultimately discharged into the atmosphere. The PPCPs excreted either from human or as metabolites reach the water treatment plant and gets discharged as raw or treated effluent[4]. These contaminants cannot be treated or removed by conventional water treatment processes. These contaminants pose risk to human health and are toxic in aquatic environment and causes risk to aquatic life[5]. Also among pathogens, it triggers resistance to antibiotics. Studies shows that the level of risk posed to human health and environment by PPCPs is not yet completely known. The main groups of pharmaceutical and personal care products (PPCPs) include: anti-bacterial, analgesics, anti- hypertensive, anti-psychoactive, anti-microbial, anti-schizophrenics, anti-depressants, stimulants[6].
1.1. Instrumentation- UV-Vis Spectrophotometry

UV-vis spectrophotometry also known as UV-vis spectrometry is used for the analysis of the particles present in the solution by the principle of absorption. It uses the light of ultra-violet and visible range. It measures the amount of light that a sample absorbs by measuring the intensity of light that passing through the sample solution[7]. Generally, a spectrophotometry consists of two instruments: spectrometer – one which is used for producing light of the required wavelength ranges 200 to 800nm, and photometer – used for measuring the intensity of light that passes through. This instrument is working based on Beer-Lambert’s Law. The law gives the quantitative relation between the solute concentration and the intensity of transmitted light. If I being the intensity of transmitted light by the sample, Absorbance (A) is defined as:

\[ A = \log \left( \frac{I_0}{I} \right) \]  

(1)

Synthetic sample solutions of Amoxicillin and Paracetamol were analysed using UV-vis Spectrometry. Initially the stock solutions of amoxicillin and paracetamol were analysed by spectrum analysis[8]. Maximum wavelength (max) and absorbance of each standard were determined. The obtained absorbance is considered as C0. Then absorbance of corresponding concentration solution was determined using UV-vis spectrometry. The absorbance was measured at maximum wavelength (nm) of its respective standard solution. The concentration showing maximum absorbance is noted as (Ct) and that particular concentration is fixed for the rest of the procedure. The obtained absorbance is taken as the concentration C0 and calculated the removal efficiency.

\[ \text{RE (\%)} = \left( \frac{C_t - C_0}{C_t} \right) \times 100 \]  

(2)

The dosage of adsorbent giving maximum absorbance is noted and chosen for the further steps of procedure. That particular dosage solution is then subjected to different rpm and temperature change. Then obtain the absorbance of that solutions and check for the percentage removal.

2. Procedure

2.1. Amoxicillin

2.1.1. Preparation of standard solution. 1.36g of KH2PO4 was weighed and taken in a 100ml volumetric flask. Then double distilled water was added to make it to the volume. 100mg of powdered amoxicillin tablet was then added to it and stirred well to dissolve. Thus prepared 100 mg/ 100 ml, i.e., 1mg/ml standard amoxicillin solution.

2.1.2. Test preparation solution. From the standard solution prepared, 1ml of solution was pipetted out into a 100 ml volumetric flask. The volume was made up to 100ml using double distilled water. Similarly, 2ml, 3ml, 4ml and 5ml of standard solution was pipetted into four different 100ml volumetric flasks, each of which the volume was made up to 100ml using distilled water. Thus different concentrations of 10,20,30,40 and 50µg/ml solutions of amoxicillin were prepared[9].

For the different concentration solutions of amoxicillin prepared, the absorbance values were obtained by analysing the concentration solutions in UV –vis spectrophotometry[10]. The pH of stock solution and concentration solution were noted. The concentration with higher absorbance value is selected as the initial concentration. The graph of concentration v/s absorbance was plotted, in which linear graph was not obtained. Since the absorbance values could not relate with the concentration values, the initial concentration cannot be fixed. Therefore, it was not proceeded further for optimizing activated carbon dosage[11].
2.2. Paracetamol

2.2.1. Standard solution preparation. 100 mg of powdered paracetamol tablet was weighed and taken in a 100 ml volumetric flask. Then added 15 ml of methanol to it and was shaken well to dissolve it. After that 85 ml of double distilled water was added to it and volume made up to 100 ml.

2.2.2. Test preparation solutions. From the standard solution prepared, 1ml of solution was pipetted out into a 100 ml volumetric flask. The volume was made up to 100ml using double distilled water. Similarly, 2ml, 3ml, 4ml and 5ml of standard solution was pipetted into four different 100ml volumetric flasks, each of which the volume was made up to 100ml using distilled water. Thus different concentrations of 10,20,30,40 and 50µg/ml solutions of paracetamol were prepared. For the different concentration solutions of paracetamol prepared, the absorbance values were obtained by analyzing the concentration solutions in UV–vis spectrophotometry[12]. The graph of concentration v/s absorbance was plotted, in which linear graph was obtained. The concentration showing maximum absorbance is noted as (Ct) here, Ct = 2.261 for Φmax = 296 nm and that particular concentration is fixed for the rest of the procedure. The obtained absorbance for each concentration is taken as the concentration C0 and calculated the removal efficiency for every optimization steps.

2.2.3. Optimization of pH. The initial concentration solution subjected to different dosages of activated carbon was fixed based on the optimum pH. For the determination of optimum pH, the initial concentration selected was 20µg/ml. From the standard solution prepared, 2ml of solution was pipetted out into a 100 ml volumetric flask. The volume was made up to 100ml using double distilled water. Thus 20µg/ml concentration solution was prepared in 6 conical flasks. The pH of solutions was changed using H2SO4 and KOH buffer solutions. Thus six different pH solutions of pH = 1, 2, 3, 4, 5, 6, 7 were obtained. Activated carbon dosage of 0.2g was added to these pH solutions. These conical flasks with different pH solutions prepared were sealed and kept in an orbital shaker for 2 hours at 150 rpm and temperature of 25±2°C. After 2hours, solutions taken from the shaker were filtered using watt man grade no: 40 filter paper. The filtered solutions were analysed in UV–vis spectrophotometry for determining their respective absorbance values. Based on the pH with higher absorbance value, the Optimum pH was selected.

2.2.4. Optimization of Concentration. Different concentrations of 10,20,30,40 and 50µg/ml solutions of paracetamol were prepared. The pH of each solution was made to the optimum pH obtained. The pH was made constant and optimized using buffer solutions. Then, activated carbon dosage of 0.2g was fixed as constant dosage, which was added to each of the concentration solutions prepared. After adding the activated carbon, the prepared solutions were placed in orbital shaker for duration of 2 hours at 150 rpm and temperature of 25±2°C. The solutions were taken from the shaker, filtered through watt man grade no: 40 filter paper and the filtrate was analysed in UV–vis spectrophotometry. The activated carbon dosage with higher percentage of removal efficiency was selected as the optimum adsorbent dosage.

2.2.5. Optimization of Activated carbon dosage. The optimum concentration obtained was fixed as the concentration solution, and the selected concentration solution was prepared in 6 different conical flasks. The pH was also made constant by making the pH of each concentration solution to optimum pH selected. Different dosages of activated carbon such as 0.025, 0.05, 0.25, 0.5, 0.75,1g/L were added to each of the conical flasks and were placed in orbital shaker for duration of 2 hours at 150 rpm and temperature of 25±2°C[14]. The solutions were taken from the shaker, filtered through watt man grade no: 40 filter paper and the filtrate was analysed in UV–vis spectrophotometry. The activated carbon dosage with higher percentage of removal efficiency was selected as the optimum adsorbent dosage.
3. Results and Discussions

3.1. Amoxicillin
The standard solutions made from the stock solutions were analysed through UV-vis spectrophotometry for the absorbance value.

Table 1. Absorbance values for different concentration Amoxicillin solutions.

| Conc. (mg/l) | Absorbance |
|-------------|------------|
| 10          | 0.008      |
| 20          | -0.007     |
| 30          | -0.007     |
| 40          | 0.038      |
| 50          | 0.055      |

Figure 1. Different concentrations of Standard Amoxicillin and their absorbance

The study gives the non-linear relation between the different initial concentration and their absorbance. Since it is non-linear, the experiment was not proceeded further for amoxicillin.

3.2. Paracetamol

3.2.1. Absorbance of different pH Paracetamol solutions prepared

Table 2. Absorbance of different pH Paracetamol solutions

| pH | Absorbance | RE%     |
|----|------------|---------|
| 1  | 1.754      | 22.42371|
| 2  | 1.727      | 23.61787|
| 3  | 1.767      | 21.84874|
| 4  | 1.765      | 21.93725|
| 5  | 1.856      | 17.91243|
| 6  | 1.796      | 20.56612|
| 7  | 1.863      | 17.60283|
Figure 2. Relation between the pH of the 20mg/L antibiotic solution and the percentage removal of the paracetamol particles.

3.2.2. Relation between standard solution absorbance v/s concentration

Table 3. Absorbance of different concentrations

| Standard Solutions | Conc. (mg/L) | Absorbance |
|--------------------|--------------|------------|
|                    | 10           | 0.04       |
|                    | 20           | 0.06       |
|                    | 30           | 0.09       |
|                    | 40           | 0.08       |
|                    | 50           | 0.12       |

Figure 3. Shows the linear relation between the different concentrations of analgesics solution and absorbance
3.2.3. Concentration optimization

**Table 4.** Absorbance of different concentration Paracetamol solutions

| Conc. (mg/L) | Absorbance | RE%      |
|--------------|------------|----------|
| 10           | 0.034      | 98.49624 |
| 20           | 0.027      | 98.80584 |
| 30           | 0.032      | 98.5847  |
| 40           | 0.097      | 95.70986 |
| 50           | 0.086      | 96.19637 |

![RE% Vs Conc.](image)

**Figure 4.** Shows the relation between different concentration of analgesics and the removal efficiency

3.2.4. Dosage optimization

**Table 5.** Absorbance with different Activated Carbon concentration

| Dosages in g/L | Dosages (mg per 20 ml) | Absorbance | RE%      |
|----------------|------------------------|------------|----------|
| 0.025          | 0.5                    | 0.112      | 95.04644 |
| 0.05           | 1                      | 0.091      | 95.97523 |
| 0.25           | 5                      | 0.082      | 96.37329 |
| 0.5            | 10                     | 0.052      | 97.70013 |
| 0.75           | 15                     | 0.101      | 95.53295 |
| 1              | 20                     | 0.059      | 97.39054 |
Figure 5. Shows the relation between different activated carbon dosages and their removal efficiency.

4. Conclusions
Unlike Amoxicillin, Paracetamol showed a linear relation between absorbance and concentration for their standard solutions of different concentration. After the optimization of pH and concentration of paracetamol synthetic solution, the removal efficiencies are determined with different dosages of activated carbon. The removal percentage was found to be higher for 0.5g/L dosage of activated carbon with initial concentration of 20mg/l analgesics solution at optimum pH 2. Therefore, the dosage of activated carbon was thus considered to be optimized, based on higher degree of removal efficiency.

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