

MICROPLASTICS BOUND TRANSPORT OF ANTIBIOTICS IN AQUATIC ENVIRONMENT

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Introduction

The global production of plastic exceeds over 300 million tons per year with an annual growth rate of 12 million tons per year. However, only 6-14% of this plastic products are recycled which means the rest is being dumped into landfills or will end up in the natural environment, lakes, rivers and oceans [1]. The large plastic debris known as 'macroplastics' so far has been the common issue disturbing the aesthetic of the marine environment, causing injury and death of marine species resulting from plastic entanglement and ingestion, translocation of non-native species, destroying marine habitats [2] whereas, 'microplastics' have been a significant discovery as a source of marine contaminant. Naturally, macroplastics breakdown to form microplastics through physical and chemical weathering such as UV degradation and mechanical abrasion due to wave and ocean current and microbial degradation. Also microplastics are synthetically produced and incorporated in cosmetics, facial cleansers and personal care products [2]. There are many size ranges to define microplastics but generally it attributes to the plastic particles in the size range of 100 nm to <5 mm diameter.

Microplastics are hydrophobic and have high surface area to volume ratio which facilitates microplastics to serve as a vector or an organic pollutant carrier through adsorption of various organic contaminant such as persistent organic pollutants (POPs), polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs) and organochlorine pesticides [3]. However, no studies have been focused on assessing the capacity of microplastics to transport antibiotics, which are emerging contaminants. Antibiotics are being detected in many waste water effluents after wastewater treatment process as many conventional treatment plants have no capacity to remove those[4]. This study is focused on how Polyethylene (PE) microplastics assist binding and transportation of ciprofloxacin hydrochloride, a broad-spectrum synthetic antibiotic used to treat wide variety of bacterial infections at different environmental conditions of varying pH, ionic strength and at the presence of organic carbon etc.

Materials and Methods

Optimum pH determination

A 100 mgL⁻¹ CPX stock solution was made by initially dissolving the solid in a minimum amount of methanol and then with de-ionized water. Polyethylene microplastic suspension of 2 gL⁻¹ was kept in the shaker for overnight for hydration and dispersion. After spiking 10 ppm of ciprofloxacin, the pH was adjusted in the range of 4 - 9 using 0.1 M HNO₃ and NaOH. At each pH, 10 ml of the sample was drawn out into separate tubes and kept shaking for 12 hours. The final pH was recorded. Samples were filtered using Polytetrafluoroethylene (PTFE) 0.45 µm filter and the absorbance was measured by the Thermo Scientific 10S UV-Vis spectrophotometer at 276 nm wavelength.

FT- IR characterization

The FT-IR analysis was done for PE microplastistics using the Thermo scientific NICOLET iS10 Fourier Transformation Infra-Red Spectrometer in the range of 550-4000 cm⁻¹.

Results and Discussion

FT-IR spectroscopic investigation

The functional groups of PE microplastics were determined by examining the IR spectrum (figure 1). IR peak at ~2916 cm⁻¹ for the -CH₂ asymmetric stretching, ~2848 cm⁻¹ for -CH₂ symmetric stretching , ~1463 cm⁻¹ for -CH₃ symmetric deformation and ~1454 cm⁻¹ for wagging were given confirming the chemical characteristics of PE [3].

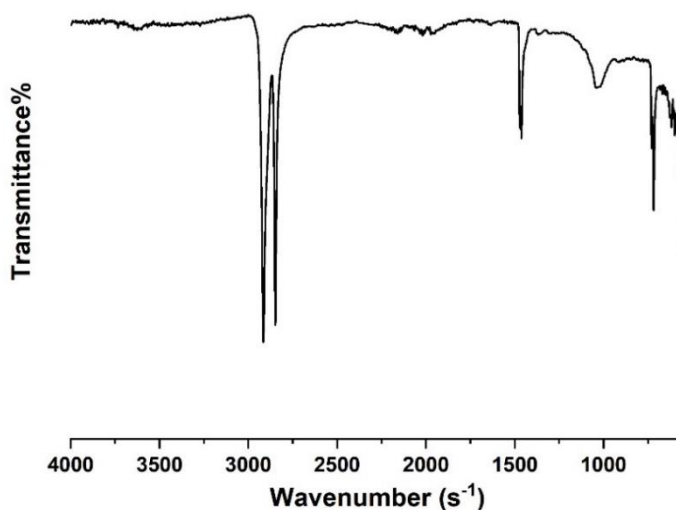


Figure 10. FT-IR microscopy spectrum of polyethylene (PE) microplastics

Effect of pH

The pH range 6 to 7 indicates a maximum adsorption whereas the adsorption capacity decreases towards lower and higher pH values (figure 2). The ionic state of CPX is influenced by different pH depending on its pKa values (pK_{a1} 6.1 and pK_{a2} 8.24). At pH below 6, due to the protonation of the -NH group CPX exists in the cationic form and pH above 8 the PCX exists in the anionic form due to the ionization of -COOH group. In between pH 6 and 8 the CPX molecule attains the zwitter ionic state where the net charge is zero[5]. The hydrophobic interactions between microplastics and CPX become prominent during this pH range exhibiting the highest adsorption of CPX by microplastics.

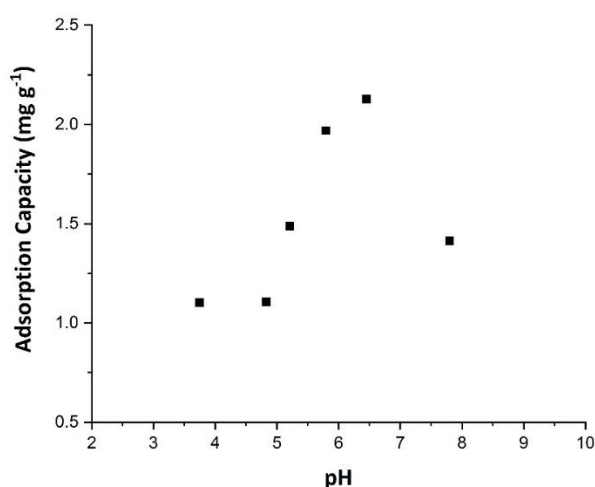


Figure 11. Adsorption capacity of CPX by the sorbent at different pH

Conclusions and Recommendations

Micro plastics are characterized with -CH₂ and -CH₃ functional groups revealing its non-polar hydrophobic properties that attribute to PE. These PE microplastics exhibit the highest adsorption capacity of CPX around neutral pH values bearing the potential of mobilizing antibiotic contaminants in the natural aquatic environment. Furthermore, FT-IR analysis for CPX bound microplastics will support further explanation towards the CPX-microplastic interaction. Future studies will be carried out for different ionic strengths (0.1, 0.01 and 0.001 M NaNO₃) and in the presence of water soluble organic compounds (Humic acid) to investigate the adsorption of microplastics and the mobility of CPX.

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