



## ***Plasma Technology for Removal of Pharmaceutical Compounds from the Environment***

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Pharmaceutical compounds are a very important and integral part of today's modern human life<sup>1</sup>. Every year, high amounts of pharmaceutical compounds are produced by pharmaceutical companies around the world to treat human, livestock, and plant's diseases. Therefore, use of these compounds increases the possibility of their introduction into the environment through various ways such as sewage, surface water, and groundwater<sup>2</sup>. The entry of these compounds into the environment has brought many environmental and health hazards, such as microbial resistance. On the one hand, microbial resistance to drugs makes microorganisms resistant to these compounds. As a result, it is highly time-consuming or even impossible to treat human and animal diseases with common drugs. On the other hand, the phenomenon of microbial resistance annually imposes huge costs on the economy, which reveals the need for a powerful removal method<sup>3</sup>. The World Health Organization (WHO) has warned about the presence of waterborne contaminants, especially in the drinking water in 2015, and has called for research to remove the contaminants and monitor the toxicity of water<sup>4</sup>.

So far, various physical, chemical, and biological methods have been used to remove these pollutants from aquatic environments, which include: activated carbon<sup>5</sup>, carbon-nanotubes<sup>6</sup>, and bio-decomposition methods<sup>7</sup>. Although these methods have a high efficiency in removal of drug compounds, but different amounts of these compounds were observed at the outlet of purification systems. Therefore, given the need for complete removal of contaminants, effective methods should be applied to hit this target. One of the recent methods for removing drug compounds from fluid environments is application of plasma. The plasma is a state of ionized gas, which is considered as the fourth state of matter and contains many quantities of charged particles such as OH, H<sub>2</sub>O<sup>+</sup>, electrons, etc.<sup>8</sup>. The plasma produced by the dielectric barriers discharge (DBD) is known as the most commonly used method because of the large amounts of high energy electrons, ultraviolet (UV), hydroxyl radicals (OH<sup>•</sup>), and oxygen radicals (O<sup>•</sup>). It also produces ozone molecules (O<sub>3</sub>) and hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>)<sup>9</sup>. The results of previous studies indicated that this method was capable of

removing or mineralizing drugs up to 100 percent by releasing these active species<sup>10</sup>. Zhang et al. showed that the method of discharging dielectric dam could remove 100 percent of norfloxacin with a concentration of 50 ppm in less than four minutes and input voltage of 10 kV in the aqueous medium<sup>2</sup>. However, in another study by Behera et al., a photocatalytic method was used in the presence of ZnFe<sub>2</sub>O<sub>4</sub>-carbon allotropes nanocomposite. This compound, with a concentration of 50 ppm over 90 minutes, was eliminated from the blue environment up to 36.90 percent<sup>11</sup>. Therefore, due to the importance of removing drug compounds from the aquatic environments, use of plasma-based methods has been highly emphasized by researchers.

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