CHAPTER 1

ADSORBENT FOR REMOVAL OF PHARMACEUTICAL COMPOUND FROM WATER

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1.1 INTRODUCTION

The pharmaceutical market and demand worldwide have reported continuous increases, driven by ageing-related and chronic disease treatment and changes in healthcare practices (González Peña et al., 2021). This increasing proportion was also contributed to by the rise in the world population; currently, the human population reached eight billion in 2022 compared to only about 2.5 billion in 1950 (DESA, 2022). Moreover, encountering the global-level pandemic in 2020–2023 with more than 700 million total cases, the pharmaceutical sector has been significantly affected by it, including the increasing demand for essential medicine supply. In the Malaysian market, pharmaceutical expenditure has emerged as the largest portion of total healthcare spending, increasing at an average annual rate of 8% over the last 10 years to account for 16.5% of total healthcare sector expenditure. For medicine expenses, the government has increased the budget allocation by 11.6% from 2010 to 2014 (Shafie et al., 2019). Moreover, pharmaceutical expenditure was expected to continue rising due to changes in lifestyle and booming economic development, and numerous

new pharmaceutical products are being developed and manufactured worldwide (Hanafiah et al., 2024). In addition, aligned with the increasing world population, the agricultural and farming (livestock, poultry, and aquaculture) sector has also bloomed significantly to cope with high demand. Thus, the unavailability of animal health diseases has also become a serious issue for breeders to maintain optimum productivity. Therefore, a significant amount of drug/medicine is required to tackle this issue.

To date, the pharmaceutical compounds have been classified into several drug classes, such as those used for anti-inflammatory/analgesics, antibiotics, antihypertensives, beta-blockers, antifungals, cardiac, antihistamines, psychiatric/antidepressants, hormones, lipid and metabolite regulators, etc. (Hanafiah et al., 2024). Among those pharmaceutical compounds, antibiotics were considered common drugs used in treating humans and animals for infections, and they have played a major role in increasing life expectancy (Qiao et al., 2018). As reported by Ariffin and Zakili (2019), there are the top 10 most commonly used pharmaceutical compounds in Malaysia are amlodipine, gliclazide, perindopril, metformin, simvastatin, hydrochlorothiazide, atenolol, acetylsalicylic acid, metoprolol, and paracetamol (PARA) (Figure 1.1).

Today, in farming and livestock industries, antibiotics are not only used to treat infections but also to help animals grow better. This leads to healthier livestock and more efficient use of feed. In the animal-producing industries, there are a number of antibiotics that were utilised, i.e., tetracyclines (TC) (33.4%), penicillin (25.5%), sulphonamides (11%), macrolides (7.5%), and polymyxins with 6.6% (Quaik et al., 2020). Therefore, it is likely that the unabsorbed medicine will pass through the blood and digestive system and end up in the manure and wastewater. The uncontrolled use of antibiotics has resulted in their presence everywhere in the environment, including soil and threatened water bodies (Dawadi et al., 2021).

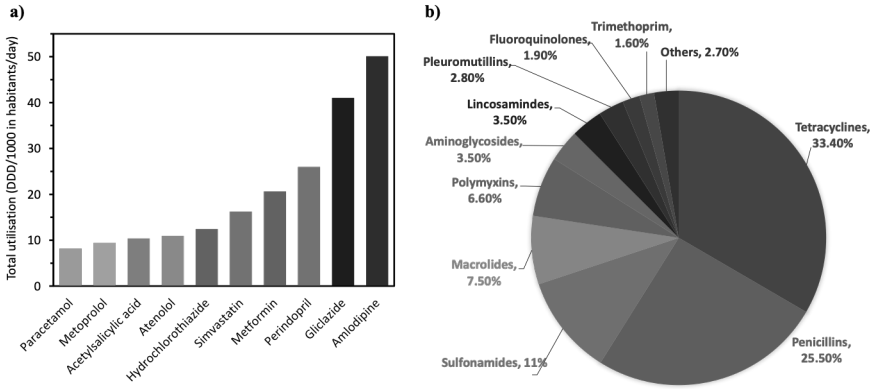

Figure 1.1 The graphical data of (a) The top ten most consumed pharmaceutical compounds in Malaysia and (b) The list of the consumed veterinary drugs (antibiotics) for food-producing poultry and livestock industries by classes in European countries (Sources: Ariffin & Zakili, 2019; Quaik et al., 2020)

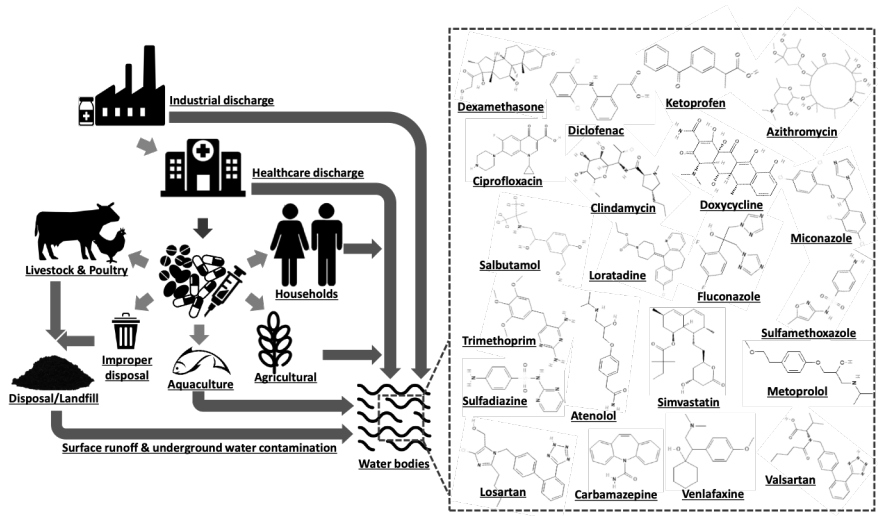

Figure 1.2 The potential pathways of the drug (pharmaceutical compound) contamination to the waste bodies (Sources: Hanafiah et al., 2024; Rayan, 2023; Stanley et al., 2022)