# UNIVERSITI TEKNOLOGI MARA

# OCCURRENCE AND REMOVAL OF ANTIBIOTIC-RESISTANT BACTERIA IN DOMESTIC WASTEWATER

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Thesis submitted in fulfillment
of the requirements for the degree of
**Doctor of Philosophy**

**Faculty of Civil Engineering**

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# AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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# ABSTRACT

Since its introduction in 1929, antibiotics is extensively used in many fields, including medicine, agriculture and aquaculture. The uncontrolled usage of antibiotics however leads to antibiotic-resistance, a phenomenon where the bacteria become immune to the antibiotics or able to resist antibiotics, resulting in ineffective treatment and new type of antibiotic has to be created. In this study, bacteria with the antibiotic resistance have found a way to wastewater treatment plant, which was proven from the presence of *E. coli, Salmonella* spp. and *Shigella* spp. in the secondary effluent of the conventional wastewater treatment plant using the secondary treatment aeration tank, with an average of $2.36 \times 10^4$, $2.61 \times 10^4$ and $3.42 \times 10^4$ CFU/mL, respectively. From the concentration, *E. coli, Salmonella* spp. and *Shigella* spp. have shown to be resistant to more than two antibiotics such as erythromycin, amoxicillin, ampicillin, cephalexin, ciprofloxacin, penicillin, cloxacillin, gentamicin, chloramphenicol, and trimethoprim-sulfamethoxazole, thus making then multidrug-resistant bacteria, with percentage range 2-100% of resistivity. Based on the results, tertiary treatments using ultraviolet (UV) and titanium dioxide ($TiO_2$) after secondary treatment are recommended to remove antibiotic resistance bacteria. From the tests performed, UV-$TiO_2$ treatments with 252 mJ/cm$^2$ of UV dosage and 1.75 g/L of $TiO_2$ are able to deactivate MDR-*E. coli* up to 7.7-log removal in UPW and 5.5-log removal in the secondary effluent. The highest MDR-*Salmonella* spp. inactivation was obtained using similar UV and $TiO_2$ doses, where they deactivate up to 6.0-log removal in UPW and 4.9-log removal in the secondary effluent. Meanwhile, MDR-*Shigella* spp. was removed using similar UV dose and 1.25 g/L $TiO_2$, up to 7.8-log removal in UPW and 5.4-log removal in the secondary effluent. All MDR-bacteria need to be inactivated before the treated water is released into the water environment because it was also found that the resistant genes found in a bacterium are transferable to other no-resistant bacteria in the system. Wastewater treatment plant causes the risk of antibiotic resistance bacteria in water bodies. *Shigella* spp. and *Salmonella* spp. were found to transfer more easily and gain the resistant gene in water environment in comparison to *E. coli*. The risk of the antibiotic resistance issue to individuals increases with the increase of contact with microorganisms. In this study, the risk analysis of human health shown by DALY indicates that human exposure to the threat of diseases caused by ARB for antibiotic-resistant levels of *E. coli, Salmonella* spp. and *Shigella* spp. were $7.92 \times 10^{-3}$, $4.6 \times 10^{-3}$ and $1.6 \times 10^{-4}$, respectively, the values are higher than the permissible limit set by the World Health Organization. Thus, there is high risk of water contamination due to pathogenic antibiotic resistant bacteria that affects humans who are in direct contact with water.

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