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PUBLIC AWARENESS LEVEL AND OCCURRENCE OF PHARMACEUTICAL RESIDUES IN DRINKING WATER WITH POTENTIAL HEALTH RISK IN KAJANG, MALAYSIA

FAUZAN ADZIMA BINTI MOHD NASIR

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By

FAUZAN ADZIMA BINTI MOHD NASIR

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September 2020

Chairman : Sarva Mangala Praveena, PhD
Faculty : Medicine and Health Sciences

The presence of pharmaceutical residues in drinking water has been a subject of concern and received growing attention from environmental and health agencies worldwide. This is because pharmaceutical residues can pose negative ecotoxicological risks from a long-term exposure. In addition, the most used conventional drinking water treatment technology is ineffective for complete removal of these pollutants. Currently there is rising on global spending for medicine however the public awareness level on its disposal practice is less explored in Malaysia. **Objective:** To study the public awareness level on drinking water quality, occurrence of pharmaceutical residues in drinking water and potential human health risks. **Methodology:** The study was conducted in selected residential areas throughout Kajang. A set of modified questionnaire was administered to the respondents to assess the public awareness level and drinking water sample was taken to analyse the occurrence of pharmaceutical residues. The drinking water samples were analysed using enzyme-linked immunosorbent assay (ELISA) and the potential human health risk were calculated. Statistical analysis involved in this study were descriptive and Spearman's rho analysis. Spearman's rho was to investigate the correlation between knowledge, attitude and practice variables for drinking water quality and pharmaceutical residues in drinking water. **Results:** In general, the Kajang population posed poor knowledge for drinking water quality (71.91%) and pharmaceutical residues in drinking water (78.65%), less positive attitude for drinking water quality (88.76%) and pharmaceutical residues in drinking water (94.38%) and poor practice for drinking water quality (58.43%) and pharmaceutical residues in drinking water (69.66%). There was a moderate positive correlation between attitude score for pharmaceutical residues in drinking water and practice score for pharmaceutical residues in drinking water ($r = 0.541$, $p = 0.000$). All the selected pharmaceuticals were presence in drinking water samples from 0.001 to 0.667 ng/L. The highest concentration was denoted

for ciprofloxacin (0.667 ng/L) while amoxicillin (0.001 ng/L) was the lowest. Nevertheless, these reported concentrations were found to be lower than studies conducted elsewhere. Besides, findings showed no adverse human health risk effect (RQ<1) from the pharmaceutical residues exposure via drinking water. **Conclusion:** This study has contributed to the extension of sparse information on public awareness level towards drinking water quality and pharmaceutical residues in drinking water in Malaysia, particularly for Kajang population. In addition, output of this study has provided information to fulfil the knowledge gap in pharmaceutical residues occurrence in drinking water and the potential human health risk. Besides, findings from this study can provide guideline to decision makers and authorities to improve current existing drinking water risk management and regulations related with emerging pollutants in Malaysia.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Master Sains

TAHAP KESEDARAN AWAM DAN KEHADIRAN SISA FARMASEUTIK DALAM AIR MINUMAN SERTA POTENSI RISIKO KESIHATAN DI KAJANG, MALAYSIA

Oleh

FAUZAN ADZIMA BINTI MOHD NASIR

September 2020

Pengerusi : Sarva Mangala Praveena, PhD
Fakulti : Perubatan dan Sains Kesihatan

Kehadiran sisa farmaseutikal dalam air minuman telah menjadi tumpuan dan mendapat perhatian daripada agensi-agensi alam sekitar dan kesihatan di seluruh dunia. Hal ini kerana sisa farmaseutikal boleh mendatangkan kesan ekotoksikologi yang dari pendedahan jangka masa panjang. Selain itu, teknologi konvensional bagi rawatan air minuman yang digunakan tidak efektif untuk menyingkirkan keseluruhan bahan pencemar ini. Pada masa ini, terdapat peningkatan dalam perbelanjaan global untuk perubatan namun tahap kesedaran masyarakat mengenai amalan pelupusannya kurang dikaji di Malaysia. **Objektif:** Untuk mengkaji tahap kesedaran awam terhadap kualiti air minuman, kehadiran sisa farmaseutikal dalam air minuman, dan potensi risiko kesihatan manusia. **Metodologi:** Kajian ini dijalankan di kawasan perumahan terpilih di seluruh Kajang Satu set soal selidik yang telah diubah suai diberikan kepada responden untuk menilai tahap kesedaran awam dan sampel air minuman diambil untuk menganalisis kehadiran sisa farmaseutikal. Sampel dianalisis menggunakan asai imunosorben untaian enzim (ELISA) dan potensi risiko kesihatan manusia dinilai. Analisis statistik yang terlibat dalam kajian ini ialah analisis deskriptif dan analisis *Spearman's rho. Spearman's rho* digunakan untuk mengkaji hubungan antara pengetahuan, sikap dan amalan terhadap kualiti air minuman dan sisa farmaseutikal dalam air minuman. **Keputusan:** Secara umumnya, penduduk Kajang memiliki tahap pengetahuan yang lemah tentang kualiti air minuman (71.91%) dan sisa farmaseutikal dalam air minuman (78.65%), sikap kurang positif terhadap kualiti air minuman (88.76%) dan sisa farmaseutikal dalam air minuman (94.38%) dan amalan kurang baik terhadap kualiti air minuman (58.43%) dan sisa farmaseutikal dalam air minuman (69.66%). Seterusnya, terdapat hubungan positif sederhana antara skor sikap bagi sisa farmaseutikal dalam air minuman dan skor amalan bagi sisa farmaseutikal dalam air minuman ($r = 0.541$, $p = 0,000$). Kesemua farmaseutikal terpilih telah dikesan di dalam sampel air minuman dengan julat kepekatan dari

0.001 hingga 0.667 ng/L. Kepekatan tertinggi telah dicatatkan bagi *ciprofloxacin* (0.667 ng/L) manakala *amoxicillin* (0.001 ng/L) pula bagi kepekatan paling rendah. Walaubagaimanapun, kepekatan yang dilaporkan didapati lebih rendah berbanding kajian-kajian terdahulu. Selain itu, analisa menunjukkan tiada risiko kesihatan manusia (RQ <1) daripada pendedahan sisa farmaseutikal melalui air minuman. **Kesimpulan:** Kajian ini telah memberikan maklumat tentang tahap kesedaran masyarakat terhadap kualiti air minuman dan sisa farmaseutikal dalam air minuman di Malaysia, terutama bagi penduduk Kajang. Di samping itu, dapatan kajian ini telah membantu perkembangan maklumat tentang kehadiran sisa farmaseutikal dalam air minuman dan potensi risiko kesihatan manusia. Selain itu, penemuan dari kajian ini dapat memberikan informasi kepada pembuat keputusan dan pihak berkuasa dalam usaha untuk meningkatkan kualiti pengurusan risiko air minuman dan menambahbaik peraturan berkaitan dengan bahan pencemar baharu di Malaysia.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Sarva Mangala Praveena, **PhD**
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Ahmad Zaharin bin Aris, **PhD**
Professor
Faculty of Forestry and Environment
Universiti Putra Malaysia
(Member)

_____
ZALILAH MOHD SHARIFF, PHD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 10 December 2020

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I hereby confirm that:

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Name and Matric No.: Fauzan Adzima binti Mohd Nasir, GS48456

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LIST OF ABBREVIATIONS

WHO	World Health Organization
STPs	sewage treatment plants
DWTPs	drinking water treatment plants
EDCs	endocrine disruptive compounds
OTC	over-the-counter therapeutic
KAP	knowledge, attitude and practice
MOA	mode of action
CNS	central nervous system
NSAIDs	non steroidal anti-inflammatory drugs
MOH	Ministry of Health Malaysia
ADHD	attention deficit hyperactivity disorder
MSOM	Malaysian Statistics in Medicines
APIs	active pharmaceutical ingredients
WWTPs	waste water treatment plants
GC-MS	gas chromatography-mass spectrometry
LC-MS	liquid chromatography-mass spectrometry
LC-MS/MS	LC tandem MS
UPLC-MS/MS	ultra-performance liquid chromatography-tandem mass spectrometry
UHPLC-MS/MS	ultra-high performance liquid chromatography-tandem mass spectometry
ELISA	enzyme-linked immunosorbent assay
DWEL	Drinking Water Equivalent Level
SYABAS	Syarikat Bekalan Air Selangor Sdn. Bhd
UTI	urinary tract infection

CHAPTER 1

INTRODUCTION

1.1 Background of study

Pharmaceuticals are synthetic or natural chemicals that can be found in prescription medicines, over-the-counter therapeutic medicines and veterinary medicines (World Health Organization [WHO], 2012). Nowadays, there are high demand for medicines associated with increasing aging population (Alkan & Elmali, 2015) and new discovered pharmaceuticals (Aitken et al., 2016). In 2024, the global spending on medicine is estimated to exceed USD 1.1 trillion whilst the spending in 2019 was USD 955 billion and in 2014 was USD 777 billion (Kleinrock & Muñoz, 2020). Similarly, global veterinary pharmaceuticals are expected to increase from USD 25 billion in 2015 to USD 39.7 billion by 2021 to cater to both food producing and companion animals (United States Department of Commerce, 2017).

Nevertheless, the ubiquitous use of medicines has led to detection of pharmaceutical residues in different water bodies and have now being recongnized as emerging contaminants. There are several pathways pharmaceutical residues can leak into the water such as improper disposal by households, human metabolic excretion and continuous extensive release from hospital, industrial and agricultural effluents (Bottoni et al., 2010; Ku¨mmerer, 2009; Segura et al., 2009). From these various sources, pharmaceutical residues then will enter sewage treatment plants (STPs). However, nowadays the STPs are not designed to quantitatively remove pharmaceutical residues causing the residuals are being released into the surface water and groundwater lakes (Gaffney et al., 2015; Houtman et al., 2014; Jurado et al., 2012; Yi Yang et al., 2017). On the other hand, veterinary pharmaceuticals applied in livestock are continuously released into the soil eventually accumulate in soil or leached into the surface water through rainwater runoff (Lyons, 2014; Snyder et al., 2008). The inevitable presence of pharmaceutical residues in surface water provides a direct route of exposure to human as conventional technology in drinking water treatment plants (DWTPs) are relatively ineffective for total removal of pharmaceutical residues (Jiang et al., 2019; Segura et al., 2009; Valcárcel et al., 2013; Yi Yang et al., 2017). As a matter of concern, unintentional pharmaceutical exposure in drinking water can evoke long-term potential human health effects.

Numerous studies were conducted to study the occurrece of pharmaceutical residues in drinking water and related risks throughout the world. The highlighted concern exist about this compunds were due to endocrine disruptive compounds (EDCs) effects. EDC is a group of exogenous organic substances that can disturb the endocrine system and the physiological function of hormones (Praveena et al., 2019). Up to 800 of EDCs are recognized that able to interfere with hormone receptors, hormone synthesis or hormone conversion (Bergman et al., 2012). However, only a small fraction of these chemicals have been

investigated in tests capable of identifying overt endocrine effects in intact organisms. Some endocrine disruptors can act directly on hormone receptors as mimicking the hormone or as antagonists. Others can act directly on any number of proteins that control the delivery of a hormone to its normal target cell or tissue. Study has been reported that EDCs can interfere with the hormones at any stage of human development. EDCs can cause morphological and functional effects in the human system, infertility as well as abnormal prenatal and childhood development (Zoeller et al., 2012). Besides that, negative effects of pharmaceutical residues also include antibiotic resistance, inhibition of primary productivity, alteration of chemical communication, and others (Jiang et al., 2019; Lin, Yu, & Chen, 2016; Padhye, Yao, Kung'u, & Huang, 2014).

1.2 Problem Statement

The occurrence of pharmaceutical residues in drinking water have been documented worldwide in various countries such as Brazil (Silveira et al., 2013), China (Leung et al., 2013a), France (Mompelat et al., 2011), Netherlands (Houtman et al., 2014), Poland (Kot-Wasik et al., 2016), Portugal (Gaffney et al., 2015), Spain (Carmona et al., 2014; Vazquez-Roig et al., 2012) and United States (Benotti et al., 2009; Padhye et al., 2014). Benotti et al., (2009) detected meprobamate (an antianxiety pharmaceutical) at 40 ng/L in drinking water. The detection more than half of finished water due to the resistant towards chlorine or ozone oxidation. Caffeine, carbamazepine, atenolol, sulfadiazine, sulfapyridine, sulfamethoxazole and erythromycin were quantified in drinking water in Portugal (Gaffney et al., 2015). Despite vast studies documented on pharmaceutical residues occurrence in drinking water, most studies conducted were from developed countries. The occurrence of pharmaceutical residues in developing countries particularly in the Malaysian is less known. In Malaysia, studies done by Al-Odaini et al., (2011) and Praveena et al., (2019) had reported the occurrence of pharmaceutical residues such as anti-diabetic, anti-hypertensive, antihistamines, antibiotics, and pain killers in drinking water. The presence of the pharmaceutical residues correlate to the same factor that was the water treatment plants and current treatment technologies used are not able to totally remove the contaminants. In addition, according to Praveena et al. (2019) the detection of caffeine in drinking water is linked to the increase in beverage and food product consumption. However, information on human health risks related to the pharmaceutical residues in drinking water of Malaysia is still limited. Besides that, according to Harmsen and Naidu, (2013) risk assessment procedure based on bioavalability is more realistic calculation rather than total concentration approach. When using the total concentration, the ingested contaminant concentration (intake) might overestimate the human health risks (Wang et al., 2013). Bioavailable is the concentration that can have an impact on humans whereas bioavailability is the proportion of the ingested contaminants that reaches the systemic circulation and can exert toxic effects. Hence, limited knowledge in bioavailability may hamper accurate human health risk assessment calculations of ingested pharmaceutical residues

Ensuring safe drinking water in a population is closely related to the public awareness level on pharmaceutical residues in drinking water. In Malaysia, the documented study is still sparse. Kioko and Obiri (2012) reported the major challenge ensuring that drinking water is safe are limited knowledge, misinformation and attitudes. This is supported by a systematic study on global pharmaceutical disposal practices by Kusturica, Tomas, and Sabo (2016) reported that common disposal practice in households was disposal in the garbage and flushing into the toilet or sink.

1.3 Conceptual Framework

Figure 1.1 shows the conceptual framework for this study. The main focus of this study is to study the occurrence of pharmaceutical residues in drinking water and quantify its potential human health risk. In addition, public awareness level were measured by assessing the knowledge, attitude and practice (KAP) scores on drinking water quality and pharmaceutical residues in drinking water. Drinking water samples were collected to determine the concentration of selected pharmaceutical residues where, a long-term exposure might triggers negative health impact (Houtman et al., 2014). The risk assessment in this study involved four age groups that are infants, children, teenagers and adults. The independent variable of this study are the pharmaceutical residues concentration in drinking waters and KAP score while the dependent variable of this study is the potential human health risk.

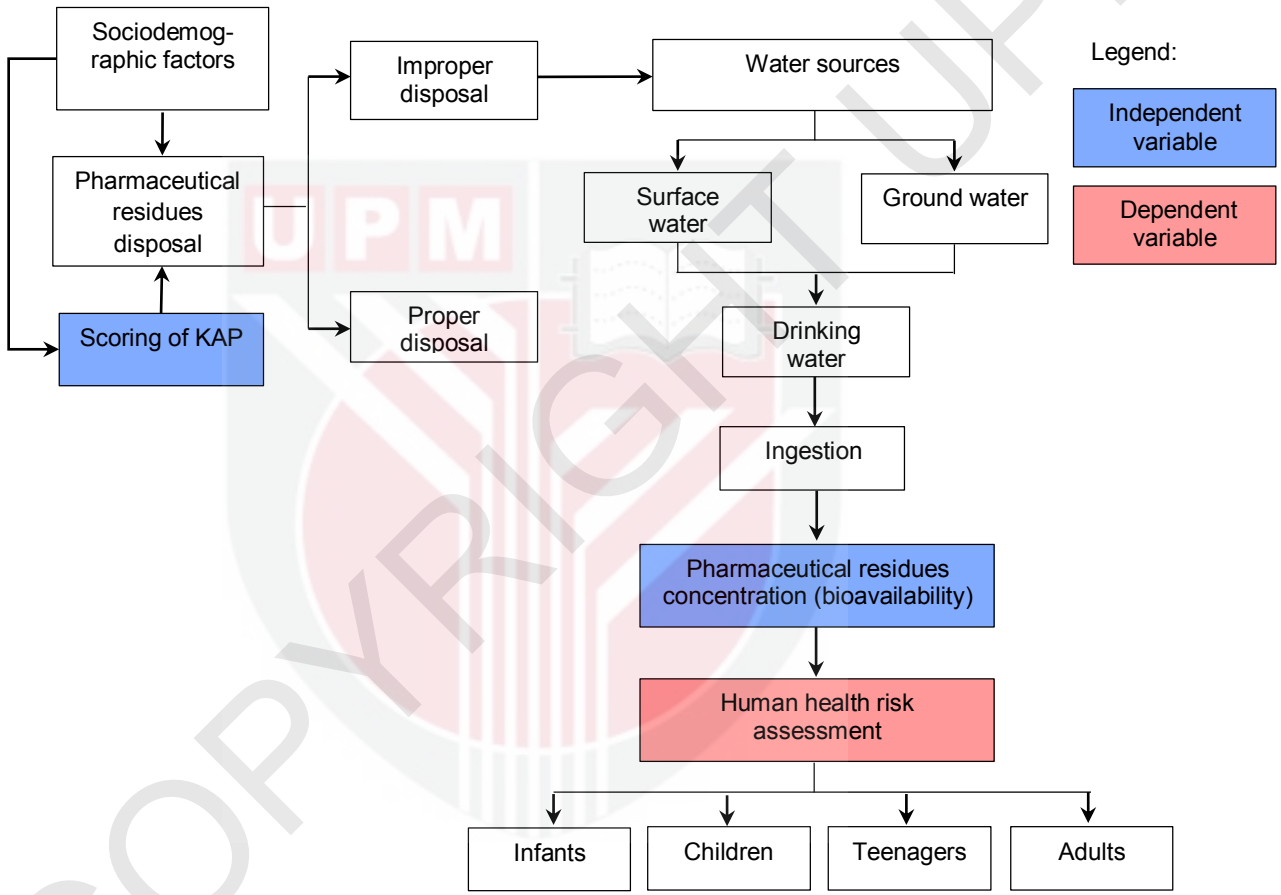

Figure 1.1 : Conceptual framework of the study

1.4 Research Objectives

1.4.1 General Objective

To study the public awareness level on drinking water quality, occurrence of pharmaceutical residues in drinking water and potential human health risks.

1.4.2 Specific Objectives

a) To determine the level of KAP on drinking water quality and pharmaceutical residues in drinking water in Kajang (Malaysia) population.

b) To investigate the relationship between knowledge and attitude, knowledge and practice and attitude and practice of drinking water quality and pharmaceutical residues in drinking water.

c) To assess the concentrations of selected pharmaceutical residues (amoxicillin, caffeine, chloramphenicol, ciprofloxacin, dexamethasone, diclofenac, nitrofurazone, sulfamethoxazole and triclosan) in drinking water from Kajang.

d) To estimate the potential human health risks of pharmaceutical residues exposure through drinking water for the Kajang population.

1.5 Research Hypothesis

a) There is significant correlation between knowledge and attitude, knowledge and practice and attitude and practice of drinking water quality and pharmaceutical residues in drinking water.

b) There is significant bioavailable concentration of pharmaceutical residues from drinking water samples of Kajang.

c) There are potential human health risks presents for pharmaceutical residues exposure via drinking water among the population of Kajang.

1.6 Research Questions

a) What are the public awareness level on drinking water quality and pharmaceutical residues in drinking water among Kajang population?

b) What are selected pharmaceutical residues concentrations in drinking water from Kajang?

c) What are the potential human health risks due to pharmaceutical residues present in drinking water consumption?

1.7 Scope and Limitation

This study is among the pioneer study in Malaysia to analyze pharmaceutical residues occurrence in drinking water. The findings provide baseline information on pharmaceutical residues concentration in drinking water and its potential human health risk which will aid the authorities in improving the drinking water risk managements and regulations in Malaysia. In addition, determination of human health risk using bioavailability concentration provide clearer finding because pharmaceutical residues only pose risk if they are in bioavailable form. Besides that, KAP survey also denoted the current public awareness level in drinking water quality and pharmaceutical residues in drinking water. By contrast, limitations of this study are the lack of chronic toxicity data used in determination of potential human health risk and the analysis of bioavailability concentration using ELISA. Result from analysis of involving ELISA is needed to be confirmed using instrumental techniques for higher degree of sensitivity. This is because instrumental techniques have great specificity which can provide accurate and precise result however ELISA analysis is good for screening purposes because it is rapid, easy to handle and cost effective compared to instrumental analysis.

REFERENCES

Ab Razak, N. H., Praveena, S. M., Aris, A. Z., & Hashim, Z. (2016). Quality of Kelantan drinking water and knowledge, attitude and practice among the population of Pasir Mas, Malaysia. *Public Health*, *131*, 103–111. https://doi.org/10.1016/j.puhe.2015.11.006

Afonso-Olivares, C., Sosa-Ferrera, Z., & Santana-Rodríguez, J. J. (2017). Occurrence and environmental impact of pharmaceutical residues from conventional and natural wastewater treatment plants in Gran Canaria (Spain). *Science of the Total Environment*, *599–600*, 934–943. https://doi.org/10.1016/j.scitotenv.2017.05.058

Afroz, R., Masud, M. M., Akhtar, R., & Duasa, J. B. (2014). Water pollution: Challenges and future direction for water resource management policies in Malaysia. *Environment and Urbanization ASIA*, *5*(1), 63–81. https://doi.org/10.1177/0975425314521544

Aini, M. S., Fakhrul-Razi, A., Mumtazah, O., & Chen, J. C. M. (2007). Malaysian households' drinking water practices: A case study. *International Journal of Sustainable Development and World Ecology*, *14*(5), 503–510. https://doi.org/10.1080/13504500709469749

Air Kelantan. (n.d.). *Proses Rawatan Air - Air Kelantan Sdn. Bhd. (AKSB)*. Retrieved July 27, 2020, from https://airkelantan.com.my/proses-rawatan-air/#/

Aitken, M., Kleinrock, M., & Nass, D. (2016). *Outlook for Global Medicines through 2021*. https://morningconsult.com/wp-content/uploads/2016/12/QuintilesIMS-Institute-Global-Outlook-FINAL.pdf

Aitken Murray. (2013). *The Global Use of Medicines : Outlook Through 2017. IMS Institute for Healthcare Informatics, New Jersey, USA.*

Al-Odaini, N. A., Zakaria, M. P., Yaziz, M. I., Surif, S., & Abdulghani, M. (2013). The occurrence of human pharmaceuticals in wastewater effluents and surface water of Langat River and its tributaries , Malaysia. *International Journal of Environmental Analytical Chemistry*, *93*(3), 245–264. https://doi.org/10.1080/03067319.2011.592949

Al-Odaini, N., Zakaria, M. P., Yaziz, M. I., & Surif, S. (2011). *Detecting Human Pharmaceutical Pollutants in Malaysian Aquatic Environment: A new challenge for water quality management*. https://www.researchgate.net/publication/279913351%0ADetecting

Al-Qaim, F. F., Jusof, S. H., Abdullah, M. P., Haider Mussa, Z., Abu Tahrim, N., Wan Mohd Khalik, W. M. A., & Othman, M. R. (2017). Determination of Caffeine in Surface Water Using Solid Phase Extraction and High Perfomance Liquid Chromatography. *Malaysian Journal of Analytical Sciences*, *21*(1), 95–104. https://doi.org/10.17576/mjas-2017-2101-11

Alan, I. S., & Alan, B. (2017). Side Effects of Glucocorticoids. In *Pharmacokinetics and Adverse Effects of Drugs - Mechanisms and Risks Factors* (pp. 93–124). IntechOpen. https://doi.org/10.5772/intechopen.72019 123

Alkan, Ö., & Elmali, K. (2015). The determination of the factors affecting pharmaceutical consumption in respect to provinces in Turkey. *Mediterranean Journal of Social Sciences*, *6*(6), 356–363. https://doi.org/10.5901/mjss.2015.v6n6p356

Allen, P., Bennett, K., & Heritage, B. (2014). *SPSS Statistics Version 22: A Practical Guide* (3rd ed.). Cengage Learning.

Almaas, H., Cases, A. L., Devold, T. G., Holm, H., Langsrud, T., Aabakken, L., Aadnoey, T., & Vegarud, G. E. (2006). In vitro digestion of bovine and caprine milk by human gastric and duodenal enzymes. *International Dairy Journal*, *16*(9), 961–968. https://doi.org/10.1016/j.idairyj.2005.10.029

American Public Health Association (AHPA), American Water Works Association (AWWA), & Water Environment Federation (WEF). (2017). *Standard Methods for Examination of Water and Wastewater* (R. B. Baird, A. D. Eaton, & E. W. Rice (eds.); 23rd ed.). American Public Health Association. https://doi.org/10.2105/SMWW.2882.216

Anderson, L. (2019). *Antibiotics Guide*. Drugs.Com. https://www.drugs.com/article/antibiotics.html

Annavarapu, S., M., J., P., K. S., Y., V. R., Raikar, S. R., & Patil, S. (2016). Knowledge , attitude and practice on safe disposal of medicines among medical and dental undergraduates. *Journal of Basic and Clinical Research*, *3*(1), 5–9. https://www.researchgate.net/publication/317303957_Knowledge_attitude_and_practice_on_safe_disposal_of_medicines_among_medical_and_dental_undergraduates

Aus der Beek, T., Weber, F.-A., Bergmann, A., Hickmann, S., Ebert, I., Hein, A., & Kuster, A. (2016). Pharmaceuticals In The Environment—Global Occurrences and Perspectives. *Environmental Toxicology and Chemistry*, *35*(4), 823–835. https://doi.org/10.1002/etc.3339

Australian Government Department of Health - Office of Chemical Safety. (2016). ADI LIST. In *Commonwealth of Australia* (Issue March).

Auta, A., Banwat, S. B., Sariem, C. N., Shalkur, D., Nasara, B., & Atuluku, M. O. (2012). Medicines in pharmacy students' residence and self-medication practices. *Journal of Young Pharmacists*, *4*(2), 119–123. https://doi.org/10.4103/0975-1483.96627

Aydin, E., & Talinli, I. (2013). Analysis, occurrence and fate of commonly used pharmaceuticals and hormones in the Buyukcekmece Watershed, Turkey.

Chemosphere, *90*, 2004–2012. http://dx.doi.org/10.1016/j.chemosphere.2012.10.074

Azad, A. K., Haque, R., Akhtaruzzaman, A., Mostofa Al-mamun, S. M., Uddin, M., & Rahman, M. M. (2012). Disposal Practice for Unused Medications among the Students of the International Islamic University Malaysia. *Journal of Applied Pharmaceutical Science*, *2*(7), 101–106. https://doi.org/10.7324/JAPS.2012.2712

Azrina, A., Khoo, H. E., Idris, M. A., Amin, I., & Razman, M. R. (2011). Major inorganic elements in tap water samples in Peninsular Malaysia. *Malaysian Journal of Nutrition*, *17*(2), 271–276.

Bahmani, M., Rafieian-Kopaei, M., Hassanzadazar, H., Saki, K., Karamati, S. A., & Delfan, B. (2014). A review on most important herbal and synthetic antihelmintic drugs. *Asian Pacific Journal of Tropical Medicine*, *7*(S1), S29–S33.

Basheer, A. O., Hanafiah, M. M., & Abdulhasan, M. J. (2017). A study on water quality from Langat River, Selangor. *Acta Scientifica Malaysia (ASM)*, *1*(2), 1–4. https://doi.org/10.26480/asm.02.2017.01.04

Benotti, M. J., Trenholm, R. A., Vanderford, B. J., Holady, J. C., Stanford, B. D., & Snyder, S. A. (2009). Pharmaceuticals and Endocrine Disrupting Compounds in U . S . Drinking Water. *Environ. Sci. Technol.*, *43*, 597–603. https://doi.org/10.1021/es801845a CCC

Bergman, Å., Heindel, J. J., Jobling, S., Kidd, K. A., & Zoeller, R. T. (2012). State of the science of endocrine disrupting chemicals. In *World Health Organisation*. https://doi.org/10.1002/9781118346747.ch1

Bernama. (2019a). Buang sisa secara haram punca LRA Sungai Semenyih tercemar. *Selangor Kini*. https://selangorkini.my/2019/12/buang-sisa-secara-haram-punca-lra-sungai-semenyih-tercemar/

Bernama. (2019b). *Pencemaran bau di sumber air mentah , 204 kawasan di Selangor bakal hadapi masalah bekalan air*. 1–3. https://www.astroawani.com/berita-malaysia/pencemaran-bau-di-sumber-air-mentah-204-kawasan-di-selangor-bakal-hadapi-masalah-bekalan-air-218726

Bhayana, K., Rehan, H. S., & Arora, T. (2016). Comparison of the knowledge, attitude, and practices of doctors, nurses, and pharmacists regarding the use of expired and disposal of unused medicines in Delhi. *Indian Journal of Pharmacology*, *48*(6), 725–728.

Boleda, M. R., Galceran, M. T., & Ventura, F. (2011). Behavior of pharmaceuticals and drugs of abuse in a drinking water treatment plant (DWTP) using combined conventional and ultrafiltration and reverse osmosis (UF/RO) treatments. *Environmental Pollution*, *159*, 1584–1591.

https://doi.org/10.1016/j.envpol.2011.02.051

Bottoni, P., Caroli, S., & Caracciolo, A. B. (2010). Pharmaceuticals as priority water contaminants. *Toxicological and Environmental Chemistry*, *92*(3), 549–565. https://doi.org/10.1080/02772241003614320

Buchberger, W. W. (2011). Current approaches to trace analysis of pharmaceuticals and personal care products in the environment. *Journal of Chromatography A*, *1218*(4), 603–618. https://doi.org/10.1016/j.chroma.2010.10.040

Buszka, P. M., Yeskis, D. J., Kolpin, D. W., Furlong, E. T., Zaugg, S. D., & Meyer, M. T. (2009). Waste-indicator and pharmaceutical compounds in landfill-leachate-affected ground water near Elkhart, Indiana, 2000-2002. *Bulletin of Environmental Contamination and Toxicology*, *82*(6), 653–659. https://doi.org/10.1007/s00128-009-9702-z

Caban, M., Lis, E., Kumirska, J., & Stepnowski, P. (2015). Determination of pharmaceutical residues in drinking water in Poland using a new SPE-GC-MS(SIM) method based on Speedisk extraction disks and DIMETRIS derivatization. *Science of the Total Environment*, *538*, 402–411. https://doi.org/10.1016/j.scitotenv.2015.08.076

Caldas, S. S., Bolzan, C. M., Guilherme, J. R., Silveira, M. A. K., Escarrone, A. L. V., & Primel, E. G. (2013). Determination of pharmaceuticals, personal care products, and pesticides in surface and treated waters: Method development and survey. *Environmental Science and Pollution Research*, *20*(8), 5855–5863.

Caracciolo, A. B., Topp, E., & Grenni, P. (2015). Pharmaceuticals in the environment : Biodegradation and effects on natural microbial communities . A review. *Journal of Pharmaceutical and Biomedical Analysis*, *106*, 25–36. https://doi.org/10.1016/j.jpba.2014.11.040

Carmona, E., Andreu, V., & Picó, Y. (2014). Occurrence of acidic pharmaceuticals and personal care products in Turia River Basin : From waste to drinking water. *Science of the Total Environment*, *484*, 53–63. https://doi.org/10.1016/j.scitotenv.2014.02.085

Castiglioni, S., Bagnati, R., Fanelli, R., Pomati, F., Calamari, D., & Zuccato, E. (2006). Removal of pharmaceuticals in sewage treatment plants in Italy. *Environmental Science and Technology*, *40*(1), 357–363. https://doi.org/10.1021/es050991m

CDC. (2018). *Active Epilepsy and Seizure Control in Adults — United States, 2013 and 2015. Morbidity and Mortality Weekly Report (MMWR) 2018*. https://www.cdc.gov/mmwr/volumes/67/wr/mm6715a1.htm?s_cid=mm6715a1

Chary, N. S., Herrera, S., Gómez, M. J., & Fernández-Alba, A. R. (2012). Parts

per trillion level determination of endocrine-disrupting chlorinated compounds in river water and wastewater effluent by stir-bar-sorptive extraction followed by gas chromatography-triple quadrupole mass spectrometry. *Analytical and Bioanalytical Chemistry*, *404*, 1993–2006. https://doi.org/10.1007/s00216-012-6251-9

Crawford, G., Hurrell, P., Paroschy, K., & Pereira, C. (2017). *Pharmaceuticals and other Endocrine Disrupting Compounds in Natural Water Systems*. *April*.

Daniel, W. W. (1999). *Biostatistics: A Foundation for Analysis in the Health Sciences* (7th ed.). John Wiley & Sons.

de Jager, C., Swemmer, A., Aneck-Hahn, N., van Zijl, C., van Wyk, S., Bornman, M., Barnhoorn, I., Jonker, M., van Vuren, J., & Burger, A. (2011). *Endocrine Disrupting Chemical (EDC) Activity and Health Effects of Identified Veterinary Growth Stimulants in Surface and Groundwater Report to the WATER RESEARCH COMMISSION*. http://www.wrc.org.za/Knowledge Hub Documents/Research Reports/1686-1-11.pdf

de Jongh, C. M., Kooij, P. J. F., de Voogt, P., & ter Laak, T. L. (2012). Screening and human health risk assessment of pharmaceuticals and their transformation products in Dutch surface waters and drinking water. *Science of the Total Environment*, *427–428*, 70–77. https://doi.org/10.1016/j.scitotenv.2012.04.010

Deng, A., Himmelsbach, M., Zhu, Q. Z., Frey, S., Sengl, M., Buchberger, W., Niessner, R., & Knopp, D. (2003). Residue analysis of the pharmaceutical diclofenac in different water types using ELISA and GC-MS. *Environmental Science and Technology*, *37*(15), 3422–3429. https://doi.org/10.1021/es0341945

Department of Environmental Quality. (2012). Storage tanks. In *Water Quality Rules and Regulations*. Department of Environmental Quality.

DrinkMore Water. (n.d.). *Drugs , Steroids , Hormones In Water*. Retrieved November 11, 2019, from https://www.drinkmorewater.com/hormones-in-water

Duan, Y. P., Meng, X. Z., Wen, Z. H., & Chen, L. (2013). Acidic pharmaceuticals in domestic wastewater and receiving water from hyper-urbanization city of China (Shanghai): Environmental release and ecological risk. *Environmental Science and Pollution Research*, *20*(1), 108–116. https://doi.org/10.1007/s11356-012-1000-3

Fasugba, O., Gardner, A., Mitchell, B. G., & Mnatzaganian, G. (2015). Ciprofloxacin resistance in community- and hospital-acquired Escherichia coli urinary tract infections : a systematic review and meta-analysis of observational studies. *BMC Infectious Diseases*, *15*(545), 1–16. https://doi.org/10.1186/s12879-015-1282-4

Fatokun, O. (2014). Exploring antibiotic use and practices in a Malaysian community. *International Journal of Clinical Pharmacy*, *36*, 564–569. https://doi.org/10.1007/s11096-014-9937-6

Fatta-Kassinos, D., Meric, S., & Nikolaou, A. (2011). Advances in Analytical Methods for the Determination of Pharmaceutical Residues in Waters and Wastewaters. *Encyclopedia of Environmental Health*, 9–16. https://doi.org/10.1016/b978-0-444-52272-6.00426-8

Fatta-Kassinos, Despo, Meric, S., & Nikolaou, A. (2011). Pharmaceutical residues in environmental waters and wastewater: Current state of knowledge and future research. *Analytical and Bioanalytical Chemistry*, *399*(1), 251–275. https://doi.org/10.1007/s00216-010-4300-9

Favrod-Coune, T., & Broers, B. (2010). The Health Effect of Psychostimulants: A Literature Review. *Pharmaceuticals*, *3*(7), 2333–2361. https://doi.org/10.3390/ph3072333

Ferguson, P. J., Bernot, M. J., Doll, J. C., & Lauer, T. E. (2013). Detection of pharmaceuticals and personal care products (PPCPs) in near-shore habitats of southern Lake Michigan. *Science of the Total Environment*, *458–460*, 187–196. https://doi.org/10.1016/j.scitotenv.2013.04.024

Fick, J., Soderstrom, H., H. Lindberg, R., Phan, C., Tysklind, M., & Larsson, D. G. J. (2009). CONTAMINATION OF SURFACE , GROUND , AND DRINKING WATER FROM PHARMACEUTICAL PRODUCTION. *Environmental Toxicology and Chemistry*, *28*(12), 2522–2527.

Fram, M. S., & Belitz, K. (2011). Occurrence and concentrations of pharmaceutical compounds in groundwater used for public drinking-water supply in California. *Science of the Total Environment*, *409*(18), 3409–3417. https://doi.org/10.1016/j.scitotenv.2011.05.053

Furlong, E. T., Batt, A. L., Glassmeyer, S. T., Noriega, M. C., Kolpin, D. W., Mash, H., & Schenck, K. M. (2017). Nationwide reconnaissance of contaminants of emerging concern in source and treated drinking waters of the United States : Pharmaceuticals. *Science of the Total Environment*, *579*, 1629–1642. https://doi.org/10.1016/j.scitotenv.2016.03.128

Gaffney, V. D. J., Almeida, C. M. M., Rodrigues, A., Ferreira, E., Benoliel, M. J., & Cardoso, V. V. (2015). Occurrence of pharmaceuticals in a water supply system and related human health risk assessment. *Water Research*, *72*, 199–208. https://doi.org/10.1016/j.watres.2014.10.027

Garcia-Ac, A., Segura, P. A., Viglino, L., Fürtös, A., Gagnon, C., Prévost, M., & Sauvé, S. (2009). On-line solid-phase extraction of large-volume injections coupled to liquid chromatography-tandem mass spectrometry for the quantitation and confirmation of 14 selected trace organic contaminants in drinking and surface water. *Journal of Chromatography A*, *1216*(48), 8518–8527. https://doi.org/10.1016/j.chroma.2009.10.015

Gil-Izquierdo, A., Gil, M. I., Tomás-Barberán, F. A., & Ferreres, F. (2003). Influence of industrial processing on orange juice flavanone solubility and transformation to chalcones under gastrointestinal conditions. *Journal of Agricultural and Food Chemistry*, *51*, 3024–3028. https://doi.org/10.1021/jf020986r

Glassmeyer, S. T., Hinchey, E. K., Boehme, S. E., Daughton, C. G., Ruhoy, I. S., Conerly, O., Daniels, R. L., Lauer, L., McCarthy, M., Nettesheim, T. G., Sykes, K., & Thompson, V. G. (2009). Disposal practices for unwanted residential medications in the United States. *Environment International*, *35*(3), 566–572. https://doi.org/10.1016/j.envint.2008.10.007

Gogtay, N. J., & Thatte, U. M. (2017). Principles of correlation analysis. *Journal of Association of Physicians of India*, *65*, 78–81.

Gómez-Oliván, A. E.-V. L. M., Galar-Martínez, M., Islas-Flores, H., Dublán-García, O., & SanJuan-Reyes, N. (2016). Amoxicillin in the Aquatic Environment, Its Fate and Environmental Risk. In *Environmental Health Risk - Hazardous Factors to Living Species* (pp. 247–267). https://doi.org/http://dx.doi.org/10.5772/57353

Green, R. J., Murphy, A. S., Schulz, B., Watkins, B. A., & Ferruzzi, M. G. (2007). Common tea formulations modulate in vitro digestive recovery of green tea catechins. *Molecular Nutrition and Food Research*, *51*(9), 1152–1162. https://doi.org/10.1002/mnfr.200700086

Griethuijsen, R. A. L. F. Van, Eijck, M. W. Van, Haste, H., Brok, P. J. Den, Skinner, N. C., Mansour, N., Gencer, A. S., & Boujaoude, S. (2015). Global Patterns in Students ' Views of Science and Interest in Science. *Research in Science Education*, *45*, 581–603. https://doi.org/10.1007/s11165-014-9438-6

Gros, M., Rodríguez-Mozaz, S., & Barceló, D. (2012). Fast and comprehensive multi-residue analysis of a broad range of human and veterinary pharmaceuticals and some of their metabolites in surface and treated waters by ultra-high-performance liquid chromatography coupled to quadrupole-linear ion trap tandem. *Journal of Chromatography A*, *1248*, 104–121. https://doi.org/10.1016/j.chroma.2012.05.084

Gupta, D., Gupta, A., Ansari, N. A., & Ahmed, Q. S. (2013). Patient's opinion and practice toward unused medication disposal: A qualitative study. *Journal of Pharmaceutical and Scientific Innovation*, *2*(5), 47–50. https://doi.org/10.7897/2277-4572.02574

GUS. (2010). *Podstawowe dane z zakresu ochrony zdrowia 2009 [Basic data on health care 2009]*. https://doi.org/ISSN 1508-1052

Hafiza, N., Razak, A., Praveena, S. M., Hashim, Z., & Zaharin, A. (2015). Drinking water studies : A review on heavy metal , application of biomarker and health risk assessment (a special focus in Malaysia). *Journal of*

Epidemiology and Global Health, *5*(297–310). https://doi.org/https://doi.org/10.1016/j.jegh.2015.04.003

Hanna, N., Sun, P., Sun, Q., Li, X., Yang, X., Ji, X., Zou, H., Ottoson, J., Nilsson, L. E., Berglund, B., Dyar, O. J., Tamhankar, A. J., & Stålsby Lundborg, C. (2018). Presence of antibiotic residues in various environmental compartments of Shandong province in eastern China: Its potential for resistance development and ecological and human risk. *Environment International*, *114*, 131–142. https://doi.org/10.1016/j.envint.2018.02.003

Harmsen, J., & Naidu, R. (2013). Bioavailability as a tool in site management. *Journal of Hazardous Materials*, *261*, 840–846. https://doi.org/10.1016/j.jhazmat.2012.12.044

Hassali, M. A., Yann, H. R., Verma, A. K., Hussain, R., & Sivaraman, S. (2018). Antibiotic Use in Food Animals : Malaysia Overview. In *Discipline of Social & Administrative Pharmacy. School of Pharmaceutical Sciences. Universiti Sains Malaysia.* School of Pharmaceutical Sciences, Universiti Sains Malaysia. https://www.reactgroup.org/wp-content/uploads/2018/11/Antibiotic_Use_in_Food_Animals_Malaysia_Overview_2018web.pdf

Horvat, A. J. M., Babić, S., Pavlović, D. M., Ašperger, D., Pelko, S., Kaštelan-Macan, M., Petrović, M., & Mance, A. D. (2012). Analysis, occurrence and fate of anthelmintics and their transformation products in the environment. *Trends in Analytical Chemistry*, *31*, 61–84.

Houtman, C. J., Kroesbergen, J., Lekkerkerker-teunissen, K., & van der Hoek, J. P. (2014). Human health risk assessment of the mixture of pharmaceuticals in Dutch drinking water and its sources based on frequent monitoring data. *Science of the Total Environment*, *496*, 54–62. https://doi.org/10.1016/j.scitotenv.2014.07.022

Houtman, C. J., ten Broek, R., & Brouwer, A. (2018). Steroid hormonal bioactivities, culprit natural and synthetic hormones and other emerging contaminants in waste water measured using bioassays and UPLC-tQ-MS. *Science of the Total Environment*, *630*, 1492–1501. https://doi.org/10.1016/j.scitotenv.2018.02.273

Huerta-fontela, M., Teresa, M., & Ventura, F. (2011). Occurrence and removal of pharmaceuticals and hormones through drinking water treatment. *Water Research*, *45*(3), 1432–1442. https://doi.org/10.1016/j.watres.2010.10.036

Huo, S.-M., Yang, H., & Deng, A.-P. (2007). Development and validation of a highly sensitive ELISA for the determination of pharmaceutical indomethacin in water samples. *Talanta*, *73*(2), 380–386. https://doi.org/10.1016/j.talanta.2007.03.055

Hussin, M. (2019). Pencemaran LRA Sungai Semenyih : Siapa perlu bertanggungjawab ? *Harian Metro*.

Jabatan Perancangan Bandar dan Desa Negeri Selangor. (2015a). *Draf Rancangan Struktur Negeri Selangor 2035*.

Jabatan Perancangan Bandar dan Desa Negeri Selangor. (2015b). *Kajian Rancangan Struktur Negeri Selangor 2035 (A2: Penduduk & Sumber Manusia)*.

Jarvis, C. I., Seed, S. M., Silva, M., & Sullivan, K. M. (2009). Educational campaign for proper medication disposal. *Journal of the American Pharmacists Association*, *49*(1), 65–68. https://doi.org/10.1331/JAPhA.2009.08032

Jiang, X., Qu, Y., Zhong, M., Li, W., Huang, J., Yang, H., & Yu, G. (2019). Seasonal and spatial variations of pharmaceuticals and personal care products occurrence and human health risk in drinking water - A case study of China. *Science of The Total Environment*, *694*, 133711. https://doi.org/10.1016/J.SCITOTENV.2019.133711

Joint FAO/WHO Expert Committee on Food Additives. (2012). *Residue evaluation of certain veterinary drugs*. http://www.fao.org/3/a-i3745e.pdf

Juahir, H., Zain, S. M., Yusoff, M. K., Hanidza, T. I. T., Armi, A. S. M., Toriman, M. E., & Mokhtar, M. (2011). Spatial water quality assessment of Langat River Basin (Malaysia) using environmetric techniques. *Environmental Monitoring and Assessment*, *173*(1–4), 625–641. https://doi.org/10.1007/s10661-010-1411-x

Jurado, A., Vàzquez-suñé, E., Carrera, J., López de Alda, M., Pujades, E., Barceló, D., López, M., Alda, D., Pujades, E., & Barceló, D. (2012). Emerging organic contaminants in groundwater in Spain: A review of sources, recent occurrence and fate in a European context. *Science of the Total Environment*, *440*, 82–94. https://doi.org/10.1016/j.scitotenv.2012.08.029

K'oreje, K. O., Vergeynst, L., Ombaka, D., De Wispelaere, P., Okoth, M., Van Langenhove, H., & Demeestere, K. (2016). Occurrence patterns of pharmaceutical residues in wastewater, surface water and groundwater of Nairobi and Kisumu city, Kenya. *Chemosphere*, *149*, 238–244. https://doi.org/10.1016/j.chemosphere.2016.01.095

K¨ummerer, K. (2010). Pharmaceuticals in the Environment. *Annu. Rev. Environ. Resour.*, *35*, 57–75. https://doi.org/10.1146/annurev-environ-052809-161223

Kasprzyk-Hordern, B., Dinsdale, R. M., & Guwy, A. J. (2009). Illicit drugs and pharmaceuticals in the environment - Forensic applications of environmental data, Part 2: Pharmaceuticals as chemical markers of faecal water contamination. *Environmental Pollution*, *157*(6), 1778–1786. https://doi.org/10.1016/j.envpol.2009.02.019

Khairudin, K. A., Abubakar Ibrahim Jatau, M. M. M., Tiong, C. S., Chitneni, M., Abdullah, A. H., Mahalingam, S. R., & Arshad, K. (2017). Utilization Pattern of Non-steroidal Anti-inflammatory Drugs at a Primary Health Care in Malaysia. *Indian Journal of Pharmaceutical Education and Research*, *51*(1), 156–161. https://doi.org/10.5530/ijper.5

Khan, U., & Nicell, J. (2015). Human Health Relevance of Pharmaceutically Active Compounds in Drinking Water. *The AAPS Journal*, *17*(3), 558–585. https://doi.org/10.1208/s12248-015-9729-5

Khan, Y. H., Sarriff, A., Khan, A. H., & Mallhi, T. H. (2014). Knowledge , Attitude and Practice (KAP) Survey of Osteoporosis among Students of a Tertiary Institution in Malaysia. *Tropical Journal of Pharmaceutical Research January*, *13*(1), 155–162. https://doi.org/10.4314/tjpr.v13i1.22

Kifli, N. (2016a). Medication Wastage and its Disposal Amongst Patients at Suri Seri Begawan Hospital in Brunei Darussalam. *Medicine & Health*, *11*(2), 139–150. https://doi.org/10.17576/mh.2016.1102.04

Kifli, N. (2016b). Medication Wastage and its Disposal Amongst Patients at Suri Seri Begawan Hospital in Brunei Darussalam. *Medicine & Health*, *11*(2), 139–150. https://doi.org/10.17576/mh.2016.1102.04

Kim, S. D., Cho, J., Kim, I. S., Vanderford, B. J., & Snyder, S. A. (2007). Occurrence and removal of pharmaceuticals and endocrine disruptors in South Korean surface, drinking, and waste waters. *Water Research*, *41*(5), 1013–1021. https://doi.org/10.1016/j.watres.2006.06.034

Kioko, K. J., & Obiri, J. F. (2012). Household attitudes and knowledge on drinking water enhance water hazards in peri-urban communities in Western Kenya. *Jàmbá: Journal of Disaster Risk Studies*, *4*(1), 1–5. https://doi.org/10.4102/jamba.v4i1.49 ©

Kleinrock, M., & Muñoz, E. (2020). *Global Medicine Spending and Usage Trends: Outlook to 2024*. https://heatinformatics.com/sites/default/files/images-videosFileContent/global-medicine-spending-and-usage-trends.pdf

Kot-Wasik, A., Jakimska, A., & Śliwka-Kaszyńska, M. (2016). Occurrence and seasonal variations of 25 pharmaceutical residues in wastewater and drinking water treatment plants. *Environmental Monitoring and Assessment*, *188*, 661. https://doi.org/10.1007/s10661-016-5637-0

Ku¨mmerer, K. (2009). The presence of pharmaceuticals in the environment due to human use – present knowledge and future challenges. *Journal of Environmental Management*, *90*, 2354–2366. https://doi.org/10.1016/j.jenvman.2009.01.023

Kuchar, E., Han, S., Karłowicz-Bodalska, K., Miśkiewicz, K., & Kutycka, E. (2014). Safety of oral ibuprofen - Analysis of data from the spontaneous

reporting system in Poland. *Acta Poloniae Pharmaceutica - Drug Research*, *71*(4), 687–690.

Kumar, A., & Xagoraraki, I. (2010). Pharmaceuticals , personal care products and endocrine-disrupting chemicals in U . S . surface and finished drinking waters : A proposed ranking system. *Science of the Total Environment*, *408*, 5972–5989. https://doi.org/10.1016/j.scitotenv.2010.08.048

Kumar, M., Jaiswal, S., Sodhi, K. K., Shree, P., Singh, D. K., Agrawal, P. K., & Shukla, P. (2019). Antibiotics bioremediation: Perspectives on its ecotoxicity and resistance. *Environment International*, *124*, 448–461. https://doi.org/10.1016/j.envint.2018.12.065

Kümmerer, K., & Henninger, A. (2003). Promoting resistance by the emission of antibiotics from hospitals and households into effluent. *Clinical Microbiology and Infection*, *9*(12), 1203–1214. https://doi.org/10.1111/J.1469-0691.2003.00739.X

Kümmerer, Klaus. (2008). *Pharmaceuticals in the Environment* (Third).

Kurt, A., Mert, B. K., Özengin, N., Sivrioğlu, Ö., & Yonar, T. (2017). Treatment of Antibiotics in Wastewater Using Advanced Oxidation Processes (AOPs). In *Physico-Chemical Wastewater Treatment and Resource Recovery 1.* (pp. 176–211). https://doi.org/http://dx.doi.org/10.5772/67538

Kuster, M., de Alda, M. J. L., Hernando, M. D., Petrovic, M., Martin-Alonso, J., & Barcelo, D. (2008). Analysis and occurrence of pharmaceuticals , estrogens , progestogens and polar pesticides in sewage treatment plant effluents , river water and drinking water in the Llobregat river basin (Barcelona, Spain). *Journal of Hydrology*, *358*, 112–123. https://doi.org/10.1016/j.jhydrol.2008.05.030

Kusturica, M. P., Tomas, A., & Sabo, A. (2016). Disposal of unused drugs : Knowledge and behavior among people around the world. *Reviews of Environmental Contamination and Toxicology*, *240*, 71–104. https://doi.org/10.1007/398_2016_3

Lee, D. H. (2018). Evidence of the possible harm of endocrine-disrupting chemicals in humans: Ongoing debates and key issues. *Endocrinology and Metabolism*, *33*(1), 44–52. https://doi.org/10.3803/EnM.2018.33.1.44

Leung, H. W., Jin, L., Wei, S., Tsui, M. M. P., Zhou, B., Jiao, L., Cheung, P. C., Chun, Y. K., Murphy, M. B., & Lam, P. K. S. (2013a). Pharmaceuticals in Tap Water : Human Health Risk Assessment and Proposed Monitoring Framework in China. *Environ Health Perspectives*, *121*(7), 839–846.

Leung, H. W., Jin, L., Wei, S., Tsui, M. M. P., Zhou, B., Jiao, L., Cheung, P. C., Chun, Y. K., Murphy, M. B., & Lam, P. K. S. (2013b). Pharmaceuticals in tap water: Human health risk assessment and proposed monitoring framework in China. *Environmental Health Perspectives*, *121*(7), 839–846.

https://doi.org/10.1289/ehp.1206244

Levin, K. A. (2006). Study design III : Cross-sectional studies. *Evidence-Based Dentistry*, *7*, 24–25. https://doi.org/10.1038/sj.ebd.6400375

Li, N., Zhang, X., Wu, W., & Zhao, X. (2014). Occurrence, seasonal variation and risk assessment of antibiotics in the reservoirs in North China. *Chemosphere*, *111*, 327–335. https://doi.org/10.1016/j.chemosphere.2014.03.129

Li, P., & Wu, J. (2019). Drinking Water Quality and Public Health. *Exposure and Health*, *11*(2), 73–79. https://doi.org/10.1007/s12403-019-00299-8

Li, W. C. (2014). Occurrence , sources , and fate of pharmaceuticals in aquatic environment and soil. *Environmental Pollution*, *187*, 193–201. https://doi.org/10.1016/j.envpol.2014.01.015

Lin, T., Yu, S., & Chen, W. (2016). Occurrence, removal and risk assessment of pharmaceutical and personal care products (PPCPs) in an advanced drinking water treatment plant (ADWTP) around Taihu Lake in China. *Chemosphere*, *152*, 1–9. https://doi.org/10.1016/j.chemosphere.2016.02.109

Lindholm-Lehto, P. C., Ahkola, H. S. J., Knuutinen, J. S., & Herve, S. H. (2016). Widespread occurrence and seasonal variation of pharmaceuticals in surface waters and municipal wastewater treatment plants in central Finland. *Environmental Science and Pollution Research*, *23*(8), 7985–7997. http://link.springer.com/10.1007/s11356-015-5997-y

Lindim, C., van Gils, J., Georgieva, D., Mekenyan, O., & Cousins, I. T. (2016). Evaluation of human pharmaceutical emissions and concentrations in Swedish river basins. *Science of the Total Environment*, *572*, 508–519. https://doi.org/10.1016/j.scitotenv.2016.08.074

Lodeiro, C., Capelo, J. L., Oliveira, E., & Lodeiro, J. F. (2019). New toxic emerging contaminants: beyond the toxicological effects. *Environmental Science and Pollution Research*, *26*(1), 1–4. https://doi.org/10.1007/s11356-018-3003-1

López-Serna, R., Pérez, S., Ginebreda, A., Petrović, M., & Barceló, D. (2010a). Fully automated determination of 74 pharmaceuticals in environmental and waste waters by online solid phase extraction-liquid chromatography-electrospray-tandem mass spectrometry. *Talanta*, *83*(2), 410–424. https://doi.org/10.1016/j.talanta.2010.09.046

López-Serna, R., Pérez, S., Ginebreda, A., Petrović, M., & Barceló, D. (2010b). Fully automated determination of 74 pharmaceuticals in environmental and waste waters by online solid phase extraction–liquid chromatography-electrospray–tandem mass spectrometry. *Talanta*, *83*(2), 410–424. https://doi.org/10.1016/J.TALANTA.2010.09.046

Lyons, G. (2014). *PHARMACEUTICALS IN THE ENVIRONMENT : A GROWING THREAT TO OUR TAP WATER AND WILDLIFE .* (Issue December). www.chemtrust.org.uk

Madikizela, L. M., Tavengwa, N. T., & Chimuka, L. (2017). Status of pharmaceuticals in African water bodies: Occurrence, removal and analytical methods. *Journal of Environmental Management*, *193*, 211–220. https://doi.org/10.1016/j.jenvman.2017.02.022

Márta, Z., Bobály, B., Fekete, J., Magda, B., Imre, T., & Szabó, P. T. (2018). Simultaneous determination of ten nonsteroidal anti-inflammatory drugs from drinking water, surface water and wastewater using micro UHPLC-MS/MS with on-line SPE system. *Journal of Pharmaceutical and Biomedical Analysis*, *160*, 99–108. https://doi.org/10.1016/j.jpba.2018.07.016

Marzura, M. ., Marni, S., & Eddy, A. . (2012). Occurrence of Veterinary Drug Residues in Livestock from Peninsular Malaysia. *International Conference on One Health and 24th VAM Congress*, *September*, 167–170.

McGettigan, P., & Henry, D. (2013). Use of Non-Steroidal Anti-Inflammatory Drugs That Elevate Cardiovascular Risk: An Examination of Sales and Essential Medicines Lists in Low-, Middle-, and High-Income Countries. *PLoS Medicine*, *10*(2). https://doi.org/10.1371/journal.pmed.1001388

Minekus, M., Alminger, M., Alvito, P., Ballance, S., Bohn, T., Bourlieu, C., Carri`ere, F., Boutrou, R., Corredig, M., Dupont, D., Dufour, C., Egger, L., Golding, M., Karakaya, S., Kirkhus, B., Feunteun, S. Le, Lesmes, U., Macierzanka, A., Mackie, A., … Brodkorb, A. (2014). A standardised static in vitro digestion method suitable for food – an international consensus. *Food Function*, *5*, 1113–1124. https://doi.org/10.1039/c3fo60702j

Ministry of Health Malaysia. (2009). Malaysian Statistics on Medicines (MSOM) 2006. In *Clinical Research Centre and Pharmaceutical Services Division, Ministry of Health*. Pharmaceutical Services Division and the Clinical Research Centre, Ministry of Health Malaysia. https://www.pharmacy.gov.my/v2/sites/default/files/document-upload/msom2006.pdf

Ministry of Health Malaysia. (2010). *Malaysian Statistics on Medicines 2007*.

Ministry of Health Malaysia. (2014). Malaysian Statistics on Medicines (MSOM) 2009 & 2010. In *Pharmaceutical Services Division And The Clinical Research Centre Ministry of Health Malaysia*. https://www.pharmacy.gov.my/v2/sites/default/files/document-upload/malaysian-statistics-medicines-2009-2010.pdf

Ministry of Health Malaysia. (2017). *Malaysian Statsitics on Medicines (MSOM) 2011-2014*. https://www.pharmacy.gov.my/v2/sites/default/files/document-upload/malaysian-statistics-medicines-2011-2014.pdf

Mompelat, S., Thomas, O., & Le Bot, B. (2011). Contamination levels of human pharmaceutical compounds in French surface and drinking water. *Journal of Environmental Monitoring*, *13*(10), 2929. https://doi.org/10.1039/c1em10335k

Montaseri, H., & Forbes, P. B. C. (2018). Analytical techniques for the determination of acetaminophen: A review. *TrAC Trends in Analytical Chemistry*, *108*, 122–134. https://doi.org/10.1016/j.trac.2018.08.023

MyHealth. (2020a). *Selangor – Hospital Kerajaan*. http://www.myhealth.gov.my/selangor-hospital-kerajaan/

MyHealth. (2020b). *Selangor – Hospital Swasta*. http://www.myhealth.gov.my/selangor-hospital-swasta/

Nannou, C., Ofrydopoulou, A., Evgenidou, E., Heath, D., Heath, E., & Lambropoulou, D. (2019). Analytical strategies for the determination of antiviral drugs in the aquatic environment. *Trends in Environmental Analytical Chemistry*, *24*, e00071. https://doi.org/10.1016/j.teac.2019.e00071

Olaniyan, L. W. B., Mkwetshana, N., & Okoh, A. I. (2016). Triclosan in water, implications for human and environmental health. *SpringerPlus*, *5*(1). https://doi.org/10.1186/s40064-016-3287-x

Omar, N A, Praveena, S. M., Aris, A. Z., & Hashim, Z. (2015). Health risk assessment using in vitro digestion model in assessing bioavailability of heavy metal in rice: A preliminary study. *FOOD CHEMISTRY*.

Omar, Noreen Adila. (2015). *Total and Bioavailability Concentrations of Heavy Metals in Variesties of Cooked Rice, and Health Risk Assessment* [Universiti Putra Malaysia]. https://doi.org/10.1145/3132847.3132886

Padhye, L. P., Yao, H., Kung'u, F. T., & Huang, C. H. (2014). Year-long evaluation on the occurrence and fate of pharmaceuticals, personal care products, endendocrine disrupting chemicals in an urban drinking water treatment plant. *Water Research*, *51*, 266–276. https://doi.org/10.1016/j.watres.2013.10.070

Peng, Y., Gautam, L., & Hall, S. W. (2019). The detection of drugs of abuse and pharmaceuticals in drinking water using solid-phase extraction and liquid chromatography-mass spectrometry. *Chemosphere*, *223*, 438–447. https://doi.org/10.1016/j.chemosphere.2019.02.040

Peng, Y., Hall, S., & Gautam, L. (2016). Drugs of abuse in drinking water – a review of current detection methods, occurrence, elimination and health risks. *TrAC - Trends in Analytical Chemistry*, *85*, 232–240. https://doi.org/10.1016/j.trac.2016.09.011

Persson, M., Sabelström, E., & Gunnarsson, B. (2009). Handling of unused

prescription drugs - knowledge, behaviour and attitude among Swedish people. *Environment International*, *35*(5), 771–774. https://doi.org/10.1016/j.envint.2008.10.002

Petrović, M., Škrbić, B., Živančev, J., Ferrando-Climent, L., & Barcelo, D. (2014). Determination of 81 pharmaceutical drugs by high performance liquid chromatography coupled to mass spectrometry with hybrid triple quadrupole-linear ion trap in different types of water in Serbia. *Science of the Total Environment*, *468–469*, 415–428. https://doi.org/10.1016/j.scitotenv.2013.08.079

Pfizer. (2018). *What are Anti-Infectives*. https://www.pfizer.com/science/therapeutic-areas/anti-infectives/what-are-anti-infectives

Prasse, C. (2012). *Analysis, Occurrence and Fate of Antiviral Drugs in the Aquatic Environment* [Universität Koblenz-Landau]. https://kola.opus.hbz-nrw.de/opus45-kola/frontdoor/deliver/index/docId/637/file/Dissertation_Carsten_Prasse.pdf

Praveena, S. M., Mohamad Shaifuddin, S. N., Sukiman, S., Mohd Nasir, F. A., Hanafi, Z., Kamarudin, N., Tengku Ismail, T. H., & Aris, A. Z. (2018). Pharmaceuticals residues in selected tropical surface water bodies from Selangor (Malaysia): Occurrence and potential risk assessments. *Science of the Total Environment*, *642*, 230–240. https://doi.org/10.1016/j.scitotenv.2018.06.058

Praveena, S. M., Mohd Rashid, M. Z., Mohd Nasir, F. A., Sze Yee, W., & Aris, A. Z. (2019). Occurrence and potential human health risk of pharmaceutical residues in drinking water from Putrajaya (Malaysia). *Ecotoxicology and Environmental Safety*, *180*, 549–556. https://doi.org/10.1016/j.ecoenv.2019.05.051

Prosser, R. S., Lissemore, L., Topp, E., & Sibley, P. K. (2014). Bioaccumulation of triclosan and triclocarban in plants grown in soils amended with municipal dewatered biosolids. *Environmental Toxicology and Chemistry*, *33*(5), 975–984. https://doi.org/10.1002/etc.2505

Prüss-ustün, A., Vickers, C., Haefliger, P., & Bertollini, R. (2011). Knowns and unknowns on burden of disease due to chemicals : a systematic review. *Environmental Health*, *10*(9), 1–15. https://doi.org/10.1186/1476-069X-10-9

Qiao, T., Yu, Z., Zhang, X., & Au, D. W. T. (2011). Occurrence and fate of pharmaceuticals and personal care products in drinking water in southern China. *Journal of Environmental Monitoring*, *13*, 3097–3103. https://doi.org/10.1039/c1em10318k

Ramamoorthy, S., & Cidlowski, J. A. (2016). Corticosteroids-Mechanisms of

Action in Health and Disease. *Rheumatic Diseases Clinics of North America*, *42*(1), 15–31. https://doi.org/10.1016/j.physbeh.2017.03.040

Rivera-Jaimes, J. A., Postigo, C., Melgoza-Alemán, R. M., Aceña, J., Barceló, D., & López de Alda, M. (2018). Study of pharmaceuticals in surface and wastewater from Cuernavaca, Morelos, Mexico: Occurrence and environmental risk assessment. *Science of the Total Environment*, *613–614*, 1263–1274. https://doi.org/10.1016/j.scitotenv.2017.09.134

Rosa Boleda, M., Huerta-Fontela, M., Ventura, F., & Galceran, M. T. (2011). Evaluation of the presence of drugs of abuse in tap waters. *Chemosphere*, *84*(11), 1601–1607. https://doi.org/10.1016/j.chemosphere.2011.05.033

Sagan, A., Panteli, D., Borkowski, W., Dmowski, M., Domanski, F., Czyzewski, M., Gorynski, P., Karpacka, D., Kiersztyn, E., Kowalska, I., Ksiezak, M., Kuszewski, K., Lesniewska, A., Lipska, I., Maciag, R., Madowicz, J., Madra, A., Marek, M., Mokrzycka, A., … Busse, R. (2011). Poland health system review. *Health Systems in Transition*, *13*(8), 1–193. https://doi.org/ISSN 1817-6127

Sanchis, A., Salvador, J., & Marco, M. (2018). Multiplexed immunochemical techniques for the detection of pollutants in aquatic environments. *Trends in Analytical Chemistry*, *106*, 1–10. https://doi.org/10.1016/j.trac.2018.06.015

Saudi, A. S. M., Kamarudin, M. K. A., Ridzuan, I. S. D., Ishak, R., Azid, A., & Rizman, Z. I. (2017). Flood risk index pattern assessment: case study in Langat River Basin. *Journal of Fundamental and Applied Sciences*, *9*(2S), 12–27. https://doi.org/10.4314/jfas.v9i2s.2

Schwab, B. W., Hayes, E. P., Fiori, J. M., Mastrocco, F. J., Roden, N. M., Cragin, D., Meyerhoff, R. D., D'Aco, V. J., & Anderson, P. D. (2005). Human pharmaceuticals in US surface waters: A human health risk assessment. *Regulatory Toxicology and Pharmacology*, *42*, 296–312. https://doi.org/10.1016/j.yrtph.2005.05.005

Schwarzenbach, R. P., Egli, T., Hofstetter, T. B., von Gunten, U., & Wehrli, B. (2010). Global Water Pollution and Human Health. *Annual Review of Environment and Resources*, *35*, 109–136.

Segura, P. A., François, M., Gagnon, C., & Sauvé, S. (2009). Review of the occurrence of anti-infectives in contaminated wastewaters and natural and drinking waters. *Environmental Health Perspectives*, *117*(5), 675–684. https://doi.org/10.1289/ehp.11776

Segura, P. A., MacLeod, S. L., Lemoine, P., Sauvé, S., & Gagnon, C. (2011). Quantification of carbamazepine and atrazine and screening of suspect organic contaminants in surface and drinking waters. *Chemosphere*, *84*(8), 1085–1094. https://doi.org/10.1016/j.chemosphere.2011.04.056

Sharaai, A. H., Mahmood, N. Z., & Sulaiman, A. H. (2010). Life Cycle Impact Assessment (LCIA) of Potable Water Production in Malaysia: A Comparison among Different Technology Used in Water Treatment Plant. *EnvironmentAsia*, *3*(1), 95–102.

Sharma, D., Patel, R. P., Zaidi, S. T. R., Rahman Sarker, Md. Moklesur Lean, Q. Y., & Ming, L. C. (2017). Interplay of the Quality of Ciprofloxacin and Antibiotic Resistance in Developing Countries. *Frontiers in Pharmacology*, *8*(546), 1–7. https://doi.org/10.3389/fphar.2017.00546

Silveira, M. A. K., Caldas, S. S., Guilherme, J. R., Soares, B. M., & Primel, E. G. (2013). Quantification of Pharmaceuticals and Personal Care Product Residues in Surface and Drinking Water Samples by SPE and LC-ESI-MS/MS. *Journal of the Brazilian Chemical Society*, *24*(9), 1385–1395. https://doi.org/10.5935/0103-5053.20130176

Simazaki, D., Kubota, R., Suzuki, T., & Akiba, M. (2015). Occurrence of selected pharmaceuticals at drinking water purification plants in Japan and implications for human health. *Water Research*, *76*, 187–200. https://doi.org/10.1016/j.watres.2015.02.059 0043-1354/©

Snyder, S. A., Vanderford, B. J., Drewes, J., Dickenson, E., Snyder, E. M., Bruce, G. M., & Pleus, R. C. (2008). *State of Knowledge of Endocrine Disruptors and Pharmaceuticals in Drinking Water*.

Sodré, F. F., Locatelli, M. A. F., & Jardim, W. F. (2010). Occurrence of emerging contaminants in Brazilian drinking waters: A sewage-to-tap issue. *Water, Air, and Soil Pollution*, *206*(1–4), 57–67. https://doi.org/10.1007/s11270-009-0086-9

Sostres, C., Gargallo, C. J., Arroyo, M. T., & Lanas, A. (2010). Adverse effects of non-steroidal anti-inflammatory drugs (NSAIDs, aspirin and coxibs) on upper gastrointestinal tract. *Best Practice and Research Clinical Gastroenterology*, *24*(2), 121–132. https://doi.org/10.1016/j.bpg.2009.11.005

Sukmasari, S., Kamarudin, A. A., Ty, T. N. F. I., & Halim, N. A. (2019). Knowledge, attitude and practice of ethnomedicine in common oral and dental diseases in patients attending IIUM dental polyclinic. *Materials Today: Proceedings*, *16*, 2219–2225. https://doi.org/10.1016/j.matpr.2019.06.113

Szymonik, A., Lach, J., & Malińska, K. (2017). Fate and removal of pharmaceuticals and illegal drugs present in drinking water and wastewater. *Ecological Chemistry and Engineering S*, *24*(1), 65–85. https://doi.org/10.1515/eces-2017-0006

Tan, E. S. S. (2012). *Method Development and Validation for Determination of Pharmaceuticals and Personal Care Products in River Water and Sewage*. Universiti Putra Malaysia.

Teixeira-Lemos, E., Teixeira-Lemos, L. P., Oliveira, J., & Pais do Amaral, J. (2018). Pharmaceuticals in the Environment: Focus on Drinking-Water. In *Encyclopedia of Analytical Science (3rd Edition)* (3rd ed., Issue June, pp. 1–11). Elsevier Inc. https://doi.org/10.1016/b978-0-12-409547-2.13941-1

Tong, A. Y. C., Peake, B. M., & Braund, R. (2011). Disposal practices for unused medications around the world. *Environment International*, *37*, 292–298. https://doi.org/10.1016/j.envint.2010.10.002

United States Department of Commerce. (2017). *Industry Focus : Animal Healthcare (Veterinary)*. https://build.export.gov/build/groups/public/@eg_main/@byind/@healthtech/documents/webcontent/eg_main_114778.pdf.

US Environmental Protection Agency. (2011). Exposure Factors Handbook: 2011 Edition. In *U.S. Environmental Protection Agency: Vol. EPA/600/R-* (Issue September). https://doi.org/EPA/600/R-090/052F

Uslu, M. O., Jasim, S., Arvai, A., Bewtra, J., & Biswas, N. (2013). A survey of occurrence and risk assessment of pharmaceutical substances in the Great Lakes Basin. *Ozone: Science and Engineering*, *35*, 249–262. https://doi.org/10.1080/01919512.2013.793595 A

Valcárcel, Y., Alonso, S. G., Rodríguez-Gil, J. L., Castaño, A., Montero, J. C., Criado-Alvarez, J. J., Mirón, I. J., & Catalá, M. (2013). Seasonal variation of pharmaceutically active compounds in surface (Tagus River) and tap water (Central Spain). *Environmental Science and Pollution Research*, *20*, 1396–1412. https://doi.org/10.1007/s11356-012-1099-2

Valcárcel, Y., González Alonso, S., Rodríguez-Gil, J. L., Gil, A., & Catalá, M. (2011). Detection of pharmaceutically active compounds in the rivers and tap water of the Madrid Region (Spain) and potential ecotoxicological risk. *Chemosphere*, *84*, 1336–1348. https://doi.org/10.1016/j.chemosphere.2011.05.014

Valera, E., Babington, R., Broto, M., Petanas, S., Galve, R., & Marco, M. P. (2013). Application of bioassays/biosensors for the analysis of pharmaceuticals in environmental samples. In *Comprehensive Analytical Chemistry* (2nd ed., Vol. 62, pp. 195–229). Elsevier B.V. https://doi.org/10.1016/B978-0-444-62657-8.00007-0

Vardanyan, R., & Hruby, V. (2016). Central Nervous System Stimulants. In *Synthesis of Best-Seller Drugs* (pp. 145–153). https://doi.org/10.1016/B978-0-12-411492-0.00008-0

Vazquez-Roig, P., Andreu, V., Blasco, C., & Picó, Y. (2012). Risk assessment on the presence of pharmaceuticals in sediments, soils and waters of the Pego-Oliva Marshlands (Valencia, eastern Spain). *Science of the Total Environment*, *440*, 24–32. https://doi.org/http://dx.doi.org/10.1016/j.scitotenv.2012.08.036

Verma, N., & Kaur, G. (2019). Advances in the oligonucleotide-based biosensors for the detection of heavy metal contaminants in the environment. In *Tools, Techniques and Protocols for Monitoring Environmental Contaminants* (pp. 169–185). Elsevier Inc. https://doi.org/10.1016/b978-0-12-814679-8.00008-x

Versantvoort, C. H. M., Kamp, E. Van De, & Rompelberg, C. J. M. (2004). *RIVM rapport 320102002 Development and applicability of an in vitro digestion model in assessing the bioaccessibility of contaminants from food* (Vol. 320102).

Vulliet, E., & Cren-Olivé, C. (2011). Screening of pharmaceuticals and hormones at the regional scale, in surface and groundwaters intended to human consumption. *Environmental Pollution*, *159*(10), 2929–2934. https://doi.org/10.1016/j.envpol.2011.04.033

Wang, C. F., & Tian, Y. (2015). Reproductive endocrine-disrupting effects of triclosan: Population exposure, present evidence and potential mechanisms. *Environmental Pollution*, *206*, 195–201. https://doi.org/10.1016/j.envpol.2015.07.001

Wang, H., Xu, W., Chen, Z., Cheng, Z., Ge, L., Man, Y., Giesy, J. P., Du, J., Wong, C. K. C., & Wong, M. (2013). In vitro estimation of exposure of Hong Kong residents to mercury and methylmercury via consumption of market fishes. *Journal of Hazardous Materials*, *248–249*, 387–393. https://doi.org/10.1016/j.jhazmat.2012.12.060

Waters Co Australia. (2019). *Why Filter Water*. https://www.waterscoaustralia.com.au/pages/why-filter-water

Weber, F.-A., Aus der Beek, T., Bergmann, A., Carius, A., Grüttner, G., Silke, H., Ebert, I., Hein, A., Küster, A., Rose, J., Koch-Jugl, J., & Stolzenberg, H.-C. (2014). *Pharmaceuticals in the e-nvironment – the global perspective*. https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/pharmaceuticals_in_the_environment_0.pdf

Wee, S. Y., & Aris, A. Z. (2017). Endocrine disrupting compounds in drinking water supply system and human health risk implication. *Environment International*, *106*, 207–233.

Wen, Z. H., Chen, L., Meng, X. Z., Duan, Y. P., Zhang, Z. S., & Zeng, E. Y. (2014). Occurrence and human health risk of wastewater–derived pharmaceuticals in a drinking water source for Shanghai, East China Zhi-HaoWen. *Science of the Total Environment*, *490*, 987–993. https://doi.org/10.1016/j.scitotenv.2014.05.087

WHO. (2008). A guide to developing knowledge, attitude and practice surveys. In *World Health Organisation*.

Wilkinson, J., Hooda, P. S., Barker, J., Barton, S., & Swinden, J. (2017).

Occurrence, fate and transformation of emerging contaminants in water: An overarching review of the field. *Environmental Pollution*, *231*, 954–970. https://doi.org/10.1016/j.envpol.2017.08.032

World Health Organization. (2011). *Guidelines for Drinking-water (Forth Edition)*. World Health Organization. http://www.who.int

World Health Organization. (2012). *Pharmaceuticals in drinking-water*.

World Health Organization. (2018). *WHO Report on Surveillance of Antibiotic Consumption: 2016-2018 Early Implementation*. https://apps.who.int/iris/bitstream/handle/10665/277359/9789241514880-eng.pdf

World Health Organization. (2019). *Pharmaceutical products*. https://www.who.int/topics/pharmaceutical_products/en/

Writer, J. H., Ferrer, I., Barber, L. B., & Thurman, E. M. (2013). Widespread occurrence of neuro-active pharmaceuticals and metabolites in 24 Minnesota rivers and wastewaters. *Science of the Total Environment*, *461–462*, 519–527. https://doi.org/10.1016/j.scitotenv.2013.04.099

Wu, C., Witter, J. D., Spongberg, A. L., & Czajkowski, K. P. (2009). Occurrence of selected pharmaceuticals in an agricultural landscape, western Lake Erie basin. *Water Research*, *43*(14), 3407–3416. https://doi.org/10.1016/j.watres.2009.05.014

Wu, Mae, Atchley, D., Greer, L., Janssen, S., Rosenberg, D., & Sass, J. (2009). Dosed without prescription: A framework for preventing pharmaceutical contamination of our nations drinking water. In *NRDC White Paper* (Issue December). https://cdn.technologynetworks.com/TN/Resources/PDF/eawhitepaper.pdf

Wu, Minghong, Xiang, J., Que, C., Chen, F., & Xu, G. (2015). Occurrence and fate of psychiatric pharmaceuticals in the urban water system of Shanghai, China. *Chemosphere*, *138*, 486–493. http://dx.doi.org/10.1016/j.chemosphere.2015.07.002

Xu, Y., Chen, T., Wang, Y., Tao, H., Liu, S., & Shi, W. (2015). The occurrence and removal of selected fluoroquinolones in urban drinking water treatment plants. *Environmental Monitoring and Assessment*, *187*, 729. https://doi.org/10.1007/s10661-015-4963-y

Yang, S. L., Tan, S. L., Goh, Q. L., & Liau, S. Y. (2018). Utilization of Ministry of Health Medication Return Programme , Knowledge and Disposal Practice of Unused Medication in Malaysia. *Journal of Pharmacy Practice and Community Medicine*, *4*(1), 7–11. https://doi.org/10.5530/jppcm.2018.1.3

Yang, Yi, Ok, Y. S., Kim, K., Kwon, E. E., & Tsangi, Y. F. (2017). Occurrences

and removal of pharmaceuticals and personal care products (PPCPs) in drinking water and water / sewage treatment plants : A review. *Science of the Total Environment*, *596–597*, 303–320. https://doi.org/10.1016/j.scitotenv.2017.04.102

Yang, Yuan-yuan, Zhao, J., Liu, Y., Liu, W., Zhang, Q., Yao, L., Hu, L.-X., Zhang, J.-N., Jiang, Y.-X., & Ying, G.-G. (2017). Pharmaceuticals and personal care products (PPCPs) and artificial sweeteners (ASs) in surface and ground waters and their application as indication of wastewater contamination. *Science of the Total Environment*. https://doi.org/10.1016/j.scitotenv.2017.10.241

Yien, T., Mangala, S., Zaharin, A., Norkhadijah, S., Ismail, S., & Rasdi, I. (2016). Analytical techniques for steroid estrogens in water samples - A review. *Chemosphere*, *165*, 358–368. https://doi.org/10.1016/j.chemosphere.2016.09.051

Yiruhan, Wang, Q. J., Mo, C. H., Li, Y. W., Gao, P., Tai, Y. P., Zhang, Y., Ruan, Z. L., & Xu, J. W. (2010). Determination of four fluoroquinolone antibiotics in tap water in Guangzhou and Macao. *Environmental Pollution*, *158*, 2350–2358. https://doi.org/10.1016/j.envpol.2010.03.019

Yuswir, N. S., Praveena, S. M., Aris, A. Z., & Hashim, Z. (2013). Bioavailability of heavy metals using in vitro digestion model: A state of present knowledge. *Reviews on Environmental Health*, *28*(4), 181–187. https://doi.org/10.1515/reveh-2013-0012

Zakaria, S. (2008). Case Study : Management Instruments for Langat River Basin. *IWRM-IHP Conference*, *March*.

Zhang, M., Shi, Y., Lu, Y., Johnson, A. C., Sarvajayakesavalu, S., Liu, Z., Su, C., Zhang, Y., Juergens, M. D., & Jin, X. (2017). The relative risk and its distribution of endocrine disrupting chemicals, pharmaceuticals and personal care products to freshwater organisms in the Bohai Rim, China. *Science of the Total Environment*, *590–591*, 633–642. https://doi.org/10.1016/j.scitotenv.2017.03.011

Zoeller, R. T., Brown, T. R., Doan, L. L., Gore, A. C., Skakkebaek, N. E., Soto, A. M., Woodruff, T. J., & Vom Saal, F. S. (2012). Endocrine-disrupting chemicals and public health protection: A statement of principles from the Endocrine Society. *Endocrinology*, *153*(9), 4097–4110. https://doi.org/10.1210/en.2012-1422

Zoorob, R. J., & Cender, D. (1998). A different look at Corticosteroids. *American Family Physician*, *58*(2), 443–450. https://doi.org/10.1148/radiol.2342040740

Zorita, S., Mårtensson, L., & Mathiasson, L. (2009). Occurrence and removal of pharmaceuticals in a municipal sewage treatment system in the south of Sweden. *Science of the Total Environment*, *407*(8), 2760–2770.

https://doi.org/10.1016/j.scitotenv.2008.12.030

Zorpas, A. A., Dimitriou, M., & Voukkali, I. (2017). Disposal of household pharmaceuticals in insular communities: social attitude, behaviour evaluation and prevention activities. *Environmental Science and Pollution Research*, 1–11. https://doi.org/10.1007/s11356-017-9551-y

Zuccato, E., Castiglioni, S., Bagnati, R., Melis, M., & Fanelli, R. (2010). Source, occurrence and fate of antibiotics in the Italian aquatic environment. *Journal of Hazardous Materials*, *179*, 1042–1048. https://doi.org/10.1016/j.jhazmat.2010.03.110

BIODATA OF STUDENT

Fauzan Adzima bt. Mohd Nasir is the daughter of Mohd Nasir bin Omar and Jamilah bt. Saleh. She was born in Hospital Bukit Mertajam, Pulau Pinang and raised in Kampung Bagan Nyiour Juru, Simpang Empat, Pulau Pinang. She started her primary school in 2000 at Sekolah Kebangsaan Juru. In 2006, she entered her first secondary school at Sekolah Menengah Kebangsan Permai Indah, Bukit Minyak until 2008. She completed her secondary school in form four and form five at Sekolah Menengah Sains Tun Syed Sheh Shahabudin, Bukit Mertajam. In 2011, she started her study at Pulau Pinang Matriculation College for one year in Life Science course. Later, in 2012 she pursued her study at Universiti Kebangsaan Malaysia (Kuala Lumpur Campus) majoring in Biomedical Sciences until 2016.

She commenced the Master of Science Degree in the field of Environmental Health under the chairmanship of Associate Professor Dr. Sarva Mangala Praveena at Faculty of Medicine and Health Sciences, Universiti Putra Malaysia started from February 2017.

LIST OF PUBLICATIONS

Mohd Nasir, F.A., Praveena, S.M., Aris, A.Z. (2019). Public awareness level and occurrence of pharmaceutical residues in drinking water with potential health risk: A study from Kajang (Malaysia). *Ecotoxicology and Environmental Safety, 185,* 109681.

Praveena, S. M., Mohd Rashid, M. Z., **Mohd Nasir, F. A**., Sze Yee, W., & Aris, A. Z. (2019). Occurrence and potential human health risk of pharmaceutical residues in drinking water from Putrajaya (Malaysia). *Ecotoxicology and Environmental Safety*, *180*, 549–556

Praveena, S. M., Mohamad Shaifuddin, S. N., Sukiman, S., **Mohd Nasir, F. A**., Hanafi, Z., Kamarudin, N., … Aris, A. Z. (2018). Pharmaceuticals residues in selected tropical surface water bodies from Selangor (Malaysia): Occurrence and potential risk assessments. *Science of the Total Environment*, *642*, 230–240.

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