Greywater discharge from household as a potential source of Pharmaceuticals Personal Care Products (PPCPs) to groundwater and surface water: A case study in Sri Lanka

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1. Abstract

This study is designed to investigate the situation of waste water management in Galle area, Sri Lanka. During the 3-week-field investigation, questionnaire survey and water sampling plan was done as an effort to understand the general sanitary situation of the area. Due to the poor wastewater management, 75% greywater from household are directly disposed to the receiving water via the drainage canals. Moreover, there is a lack of guidance for the disposal of unwanted medicine and personal care products, which is indicated by 65% and 22% respondent answered that they will dispose to as garbage or flush to the toilet. This fact has risen the threat of the introduction of emerging contaminants into the water resource and the negative impact to the ecology and human health in case of chronic exposure. Water samples were extracted to determine the occurrence of pharmaceutical and personal care products in water resource. From this preliminary study, further work can be considered to help improve the sanitary facility in Galle area toward the United Nation goal number 6 Clean water and sanitation.

2. Field investigation period:

Duration: From 2018/08/06 to 2018/08/24

The field investigation included two phases:

- From 06/08 to 17/08: samples collection and working in laboratory
- From 19/08 to 24/08: field survey using questionnaires

3. Background

According to UNDP, 80% of wastewater from human activities is discharged into waterways without any pollution removal. Recently, the pollutants from human daily activities turn out to be more complicated due to the widely consumption of a large amount of modern lifestyle products. One of the emerging pollutants that currently draws attention of global researchers is pharmaceuticals and personal care products (PPCPs). PPCPs is defined as prescription, over the counter and veterinary drugs used to prevent or cure human or animal diseases, while personal care products are a group

of organic chemicals in various daily life products e.g. cosmetic, body and hair care, cleansing products or even in food and beverage. Possible source of PPCPs are wastewater from populated residential areas, hospital, landfill, sewage treatment plants, livestock breeding etc. Although it is found in a low range concentration (ng/L to μg/L), the bioaccumulation characteristic of PPCPs in aquatic environment may pose potential chronic exposure to the ecosystem and human health.

The poor domestic discharges management in developing countries such as Sri Lanka has risen a threat to the freshwater resource i.e. groundwater and surface water. This case study was conducted in Galle area, capital of the Southern Province of Sri Lanka. In this area, domestic waste water is not collected and treated completely and most of the cases directly discharged to the receiving water without proper treatment. The only sewage treatment plants (STPs) in Galle is negligible to the population and also, the technology used in these STPs is out of date.

4. Objective

The lack of understanding about the toxicity, behaviors and impacts of PPCPs are the reason why PPCPs are not routinely monitored and regulated. In countries where the wastewater management is poor, the improper use and disposal of PPCPs also considered a source of PPCPs to the environment. My research objectives are (1) to evaluate the situation of wastewater system and the consumer behavior toward the use of PPCPs and (2) to address the occurrence of the emerging pollutants PPCPs in water environment in the sub-urban area in Galle, Sri Lanka.

As far as my knowledge, this is the first study concern about the emerging pollutant in Sri Lanka. The case study would provide preliminary information regarding the current sanitation facilities and practice in Galle area. From this initial fundamental understanding, water- and sanitation-related activities and programs would be considered and supported by national and international cooperation in order to help the country to reach the target of Sustainable development goals by 2030.

5. Method

This research is an experimental one including:

- Water samples collection, field measurement and chemical analyzing in laboratory
- Questionnaire survey, visiting household in Galle area and individual interview to residents

Detail of methodology is described following:

5.1. Water samples collecting

Water samples are collected from different sources such as household discharge, groundwater, river water, Galle city canal system which discharge wastewater to the sea, drinking bottle water. Each type of sample need to be collected, preserved and stored following a specific protocol to ensure the precise of the chemical analysing data. Polypropylene bottles (250 mL or 500 mL) are used to collect water. All bottles are cleaned carefully with distilled water twice, methanol once and dry in room temperature before use. When collecting water samples, always wear gloves for self-safety and prevent cross contamination between samples. At each site, before collecting sample, bottles were labelled and information about the site such at coordinates, weather, special note were noted. After that, portable devices were used to measure temperature, pH and electrical conductivity of the water. The samples were kept cool until transported to the Engineering Department, Ruhuna University. Samples were acidified by formic acid to pH2 before keeping frozen.

5.1.1. Greywater from household

The greywater samples were collected from 3 households from in Galle area Hangman, Galle city and Elpitiya. Greywater from kitchen, bathroom and laundry is collected separately 3-4 times during the day and mixed well to a final 250 mL composite sample. Composite sample include greywater during the day, not only in a specific time so its characteristic is representative. Diagram in Fig. 1 clearly describes the labor and time demanding process of the greywater sampling which may take a day at the site.

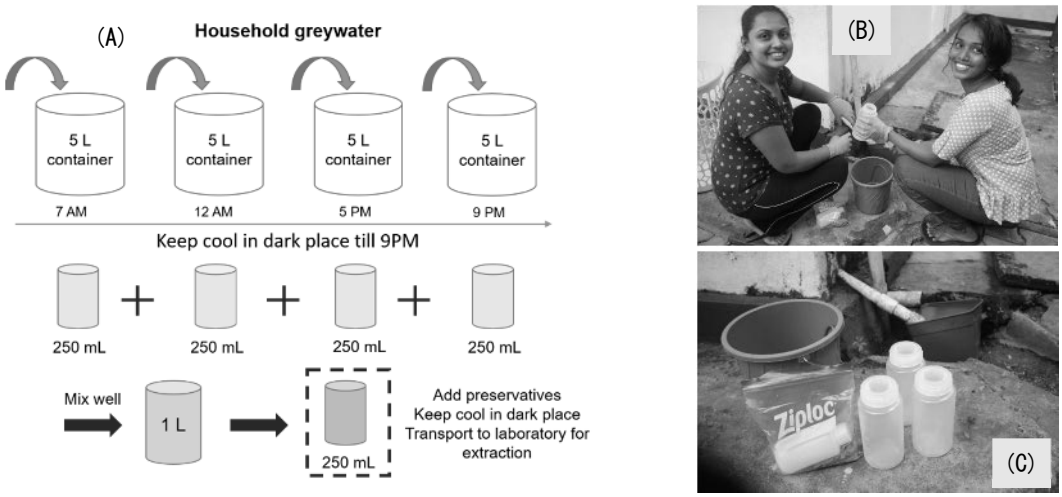

Figure 1. (A) Household greywater composite sampling; (B, C) Collecting samples at household

Groundwater from the same household were also collected. High quantities of nutrients or other dissolved chemicals in surface water can be transferred to the connected groundwater system. Therefore, it is necessary to concern about the possibility of polluted groundwater in this area.

5.1.2. River and drainage canal

Gin River is one of the major rivers in Southern Province. Along the river, people use river water for bathing, washing clothes and sometimes for drinking even. National Water Supply and Drainage Board (NWSDB) has obtained water from this river to the water treatment plant, which supplies drinking water for Galle area. Sampling sites are shown in the map in Fig.2. With the assistance of Google Earth tool, it is possible to view images from the location and access information on the terrain of the location. The bridges along the river and canals were selected as the site to collect the surface water. Water were obtained from the bridge, at the middle of the canal/river by using a bucket and long rope.

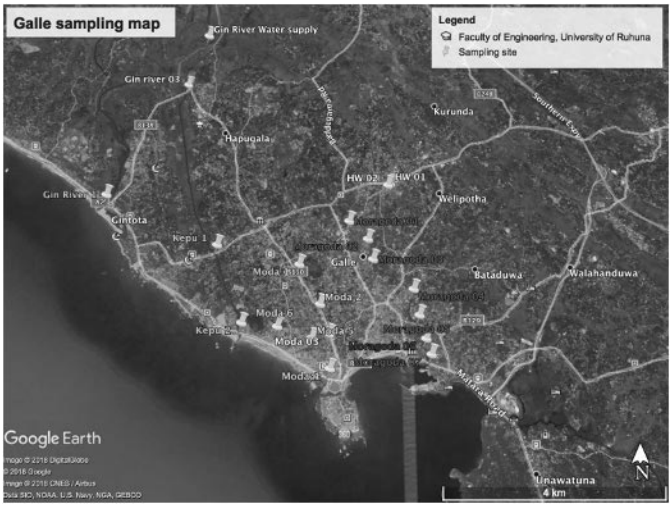

Figure 2. Water sampling map in Galle city

The Galle District's drainage system comprises of a network of large open canals including MoragodaEla, KepuEla and ModaEla. 75% of the domestic wastewater of Galle District was collected and discharged into the sea. Water samples from these canals will provide information about the PPCPs occurrence in water environment and also wastewater-based demographic biomarkers.

Figure 3. Collecting water samples (from left to right: tuktuk vehicle to transport between sampling sites; collect water from the bridge, measure field parameter using portable device)

5.1.3. Chemical analyzing

PPCPs is micro-pollutants in greywater and environmental water which can be concentrated using solid phase extraction. Collected samples from Sri Lanka will be extracted at Ruhuna University, Galle, Sri Lanka following US.EPA Method 1694 (Pharmaceuticals and Personal care products in water, soil, sediment and biosolids by HPLC/MS/MS, EPA, 2007) with minor adaptation from previous studies (Lin Ma et al., 2018; Edward Archer et al., 2017; Bruce Petrie et al., 2016; Kunde Lin et al., 2011). The cartridges then will be frozen and carried to Ochanomizu University for the remaining steps and analyzing using high performance liquid chromatography (HPLC) technique.

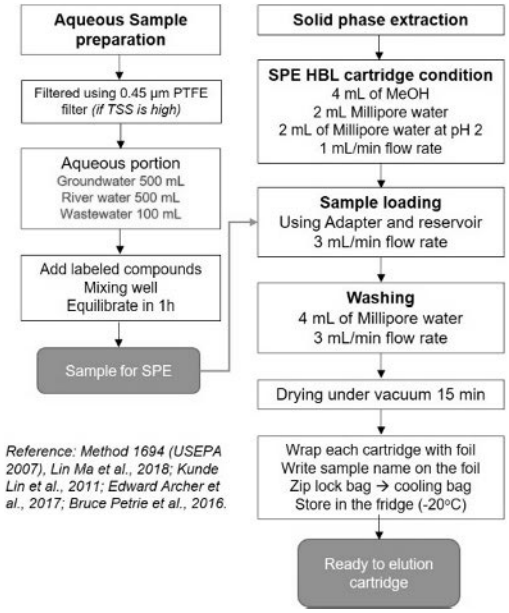

Figure 4. Water samples PPCPs extraction procedure

Supelco Select HLB cartridge (6 cc, 200 mg) was selected as it utilizes both hydrophilic and lipophilic retention mechanism at neutral pH. Consequently, it is appropriate for broad range extraction of PPCPs simultaneously in different environmental matrices.

5.2. Questionnaire survey

The objectives of the survey is to:

- To describe water use and treatment and disposal practices at the household level
- To shortlist the type of consumed pharmaceuticals and household products
- To understand the PPCPs disposal practice from households

Number of questionnaire: 100

The survey was done with the great assistance of the local students from Ruhuna University. The survey was done in 5 days from 19-23 August 2018. The team went to the residential areas in Galle city and Ahangama village, famous as tourist attraction spot. Then we divided into small group and visit the houses for individual survey and also visit the wastewater treatment system in their houses.

Figure 5. Questionnaire surveys at household in Galle

6. Results and Discussion

6.1. Water use and wastewater disposal practice

88.5% household are using the supply water from National Water Supply and Drainage Board (NWSDB, 2013). Groundwater is not commonly used and only used for non-drinking purpose.

Regarding the wastewater disposal practice, from the observation in the previous visits, we can summarize different wastewater treatment methods in Galle area. The pit (Fig 6A) is only the soil pit 1-2 meters deep, with side wall is soil only or concrete and covered. The wastewater is simply collected and then penetrate to the ground. This method need to be improved to meet environmental regulation. The septic tank is the standardized method with the side wall and bottom are concrete. The size of the septic tank depends on the house size or number of user. There are septic tank with and without treatment (Fig 6B, 6C). Buffalo tank is the new and advanced method including a horizonal tank connected to a vertical tank (Fig 6D).

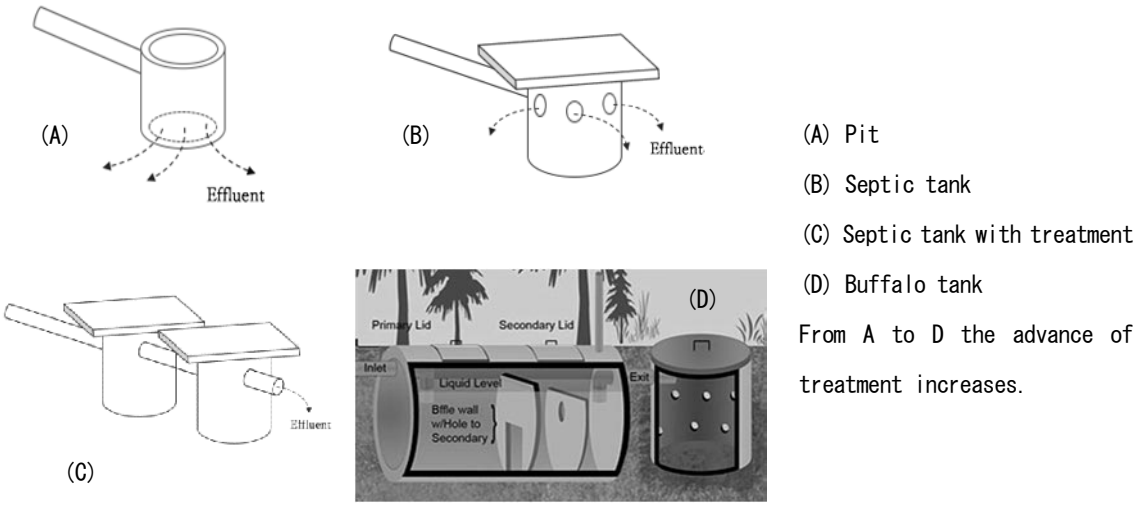

Figure 6. Wastewater treatment practice in Galle area.

Overall, the black water i.e. wastewater from toilet are collected and there is no open defecation. However, 73% households are using the least simple method – covered pit for the wastewater. Only 15% samples are using septic tank and 12% are using buffalo tank (Fig 7).

On the other hands, majority of greywater discharged from kitchen, bathroom and laundry remain uncollected and the disposal is through sewage pipes to the back yard (common in village) or connect to the drainage system that's connect to the city canals (in city area). Approximately 15% and 2% of greywater are collected together with black water to the pit and septic tank, respectively.

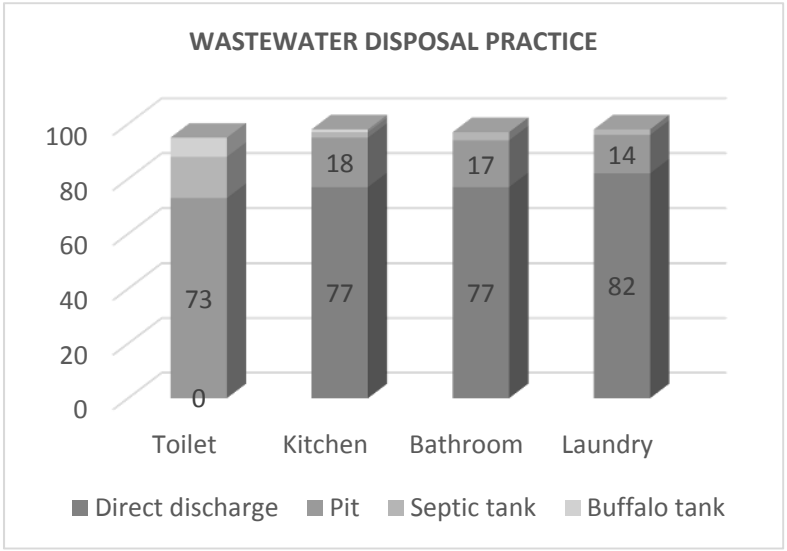

Figure 7. Wastewater disposal and treatment practice in Galle area

Regarding the sewage treatment plant in this area, Hikkaduwa is the only one sewage treatment facility in of Galle district. The capacity of the system is 3.3 million liters per day. Wastewater treatment process is Facultative pond and Polishing ponds (NWSDB, 2013). Total volume of domestic wastewater generated in Galle District was estimated of 111 mil liters per day (TBRC Analysis, Sri Lanka Government, 2017). Consequently, it can be calculated that 107.7 mil litres wastewater per day remaining untreated and disposed to open canals and finally into the sea.

When being asked about the greywater reuse, 85.6% and 60.8% respondent thinks it is safe to use greywater for irrigation and toilet flushing. However, 15% respondents are actually reusing greywater, mainly for irrigation and gardening.

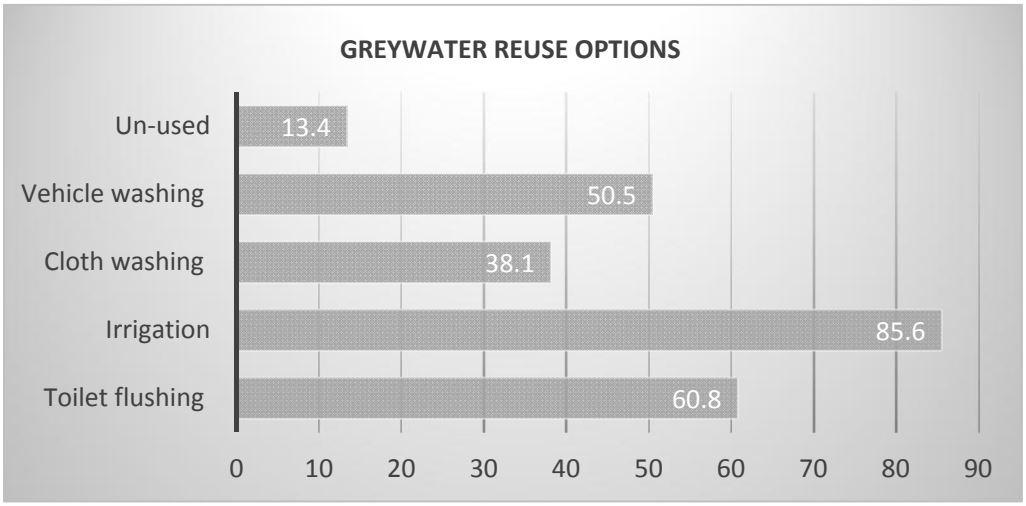

Figure 8. Greywater reuse options of Galle area residents

40.7% households have washing machine, waste water from this source can be collected and used for various purpose such as floor washing, toilet flushing, gardening if there is proper treatment. A further study relating to this aspect is being conducted. Then it would be more persuasive practice for the residents to apply the recycling practice.

6.2. Consumption and disposal of PPCPs

Various chemical household products are used widely in Galle area such as: cleansing product, disinfection, hair and body care etc. as the global modern lifestyle. When being asked the decisive factors they concern when purchase the household product, 30% and 33% responded personal preferences and the product quality. Brand

familiarity and price are also put into consider of average 15% of the total answers. Only a minority 5% considered about the environmental friendly aspect of the products. This is contrast to the trend of developed countries where consumers prefer organic products and prevent using chemical added products.

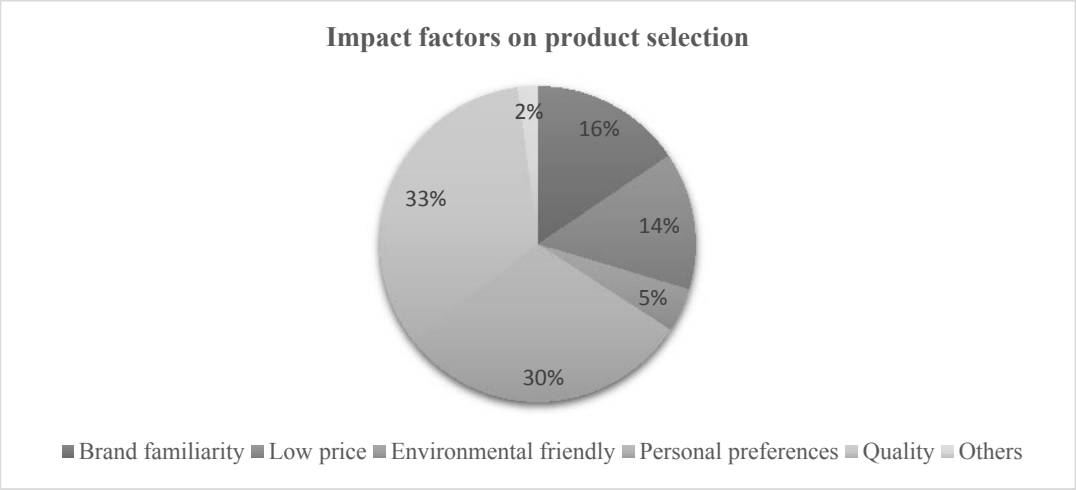

Figure 9. Impact factors to household products selection of consumers in Galle, Sri Lanka

Regarding the pharmaceutical, there are 57% respondents reported they are using long-term prescribed medicine. Common diagnoses are high blood pressure, cardiovascular problem, high blood cholesterol, diabetes. Most of the medicine users remain unaware about the disposal of unused or expired medicines. This fact raises threat about their impact on the environment and contamination of surface and drinking water supplies.

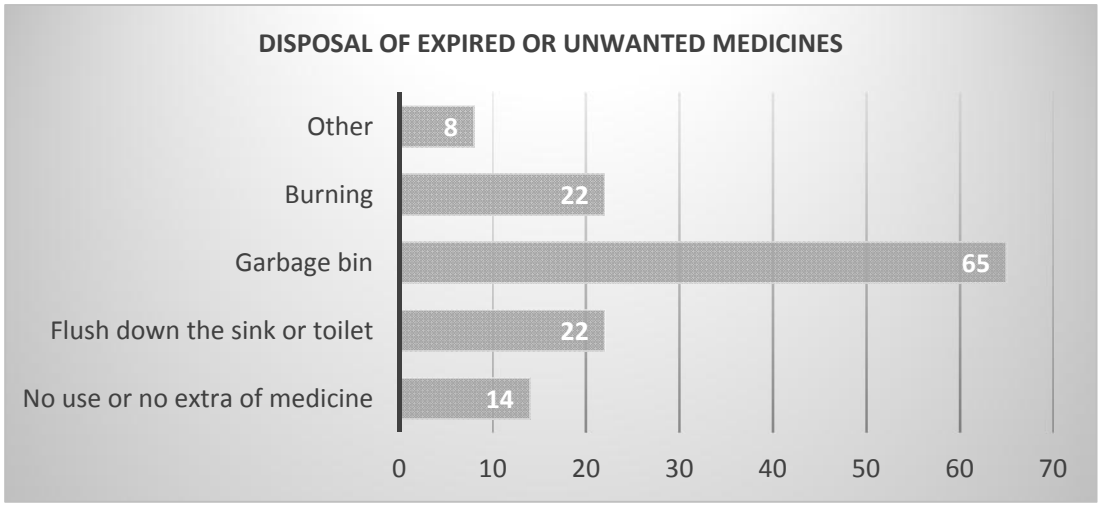

Figure 10. Behaviour of PPCPs disposal of Galle area

6.3. PPCPs concentration

Influent and effluent sample collected from Hikkaduwa STP were tested in a screening test of 82 commonly used PPCPs. Of these, 19 compounds were detected in influent samples and 20 compounds of that in effluent samples. Several compounds are found in high concentration such as: Acetaminophen, carbamazepine, DEET and caffeine. Previous studies consistently showed that these 4 PPCPs are in the common list of PPCPs detected in water (Qian Sui et al., 2015). Regarding to the types of PPCPs were found from the samples, dominant groups are antibiotic (7 compounds), Non-steroidal anti-inflammatory drugs (3 compounds) and hypertensive or heart disease drug (6 compounds). More samples from the August field trip will be analyzed and provide more details about the situation of the research site. Currently, the samples are ready, however the instruments need to be adjusted to meet the requirement for chemical analyzing.

7. Future prospects

In the next step, further survey can be continued to focus to the consummer behaviours related to gender. Educational campaign are essential to enhance the understanding of future waste disposal among families. My ambition is to provide community with the information on safe and standard pharmaceutical waste. The fact that the residents have no idea of a proper way to dispose waste would help the policymakers to take firm steps to encourage wastewater management in general and standard pharmaceutical waste management in specific.

Moreover, one of the students in Ruhuna University is now doing research on greywater recycling for non-drinking purpose use. We will definitely share experience and knowledge to realize the idea. This would be alternative option for the sanitation facility in the situation that new wastewater treatment plant could not be scheduled in short time. Although the water shortage is not a problem in this area, the recycling and reuse practice will release the pollutants loading to wastewater treatment plant and the environment.

References

Archer Edward, P. B. H. (2017), "The fate of pharmaceuticals and personal care products (PPCPs), endocrine disrupting contaminants (EDCs), metabolites and illicit drugs in a WWTW and environmental waters." *Chemosphere*. 174: pp.437-446.

Bruce Petrie, J. Y. (2016), "Multi-residue analysis of 90 emerging contaminants in liquid and solid environmental matrices by ultra-high-performance liquid chromatography

tandem mass spectrometry." *Journal of Chromatography A*. 1431: pp.64-78.

Carmona E. (2017), "Multi-residue determination of 47 organic compounds in water, soil, sediment and fish—Turia River as case study." *Journal of Pharmaceutical and Biomedical Analysis.* 146: pp.117-125.

Ebele Anekwe Jennifer, A.-E. A. (2017), "Pharmaceuticals and personal care products (PPCPs) in the freshwater aquatic environment." *Emerging Contaminants*. 3: pp.1-16.

L. Ma, Y. L. (2018), "Impacts of irrigation water sources and geochemical conditions on vertical distribution of pharmaceutical and personal care products (PPCPs) in the vadose zone soils." *Science of the Total Environment.* 626: pp.1148-1156.

Lin Kunde, J. G. (2011), "Sorption and degradation of wastewater-associated non-steroidal anti-inflammatory drugs and antibiotics in soils." *Chemosphere*. 83.3: pp. 240-246.

Sui Qian, C. X. (2015), "Occurrence, sources and fate of pharmaceuticals and personal care products in the groundwater: A review." *Emerging Contaminants*. pp. 14-24.

Turner, R. (2017), *Environment implications of greywater irrigation within an urban development*, QUT PhD Thesis.

USEPA (2007), *Method 1694: Pharmaceuticals and Personal Care Products in Water, Soil, Sediment, and Biosolids by HPLC/MS/MS.*

National Water Supply and Drainage Board (NWSDB) (2013), *Wastewater sector and wastewater system in Sri Lanka.*