RESEARCH REPORT

Understanding and quantifying macro-plastics litter in the Turitea Stream

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Advanced Zero Waste for Sustainability

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1.0 Introduction

Plastic litter is a global environmental concern. It is known that more than 80% plastic litter in the ocean originates on land through rivers and streams as major source (Derraik, 2002; van Emmerik, 2018). The amount of plastic products such as single-use plastic bags and food packaging have become significant source of pollution into rivers and eventually into the marine environment (Xanthos & Walker, 2017; Jambeck et al., 2015). The marine environment plays important role as resources for human and marine biota however, plastic pollution has become a significant threat to it. This causes significant economic and social costs besides reduce the aesthetic and intrinsic values of the marine environment (Derraik, 2002). Understanding the point of source where the plastics originated in rivers could assist in management of this form of pollution. While most of the studies on plastic pollution conducted in marine environment, very few studies in rivers or other waterways. This study will be focusing on freshwater ways including rivers and streams plastic pollution.

This research project is an adaptation of and addition to the Palmy's Plastic Pollution Challenge (PPPC), which will extend the baseline data. The study aims to understand the amount and type of macro-plastics rubbish that may have lost into the stream systems due to mismanagement or littering. As this study adopted from PPPC methods, it was conducted as continuation of stream plastic debris pollution to quantify and sort type of plastic in the Turitea Stream including Kahuterawa Stream, which then complete the 'whole city' plastic pollution survey. The rubbish collected, sorted out from selected sites within Turitea Stream and compared the abundance and types of plastic waste from the Turitea Stream sites with the broader existing PPPC dataset. Quantifying the amount of macro-plastic debris and other rubbish that may also be found in this stream will enable comparison with other data from other New Zealand urban waterways and will support better management of plastic waste into the river and stream systems. The study used methods to address the questions of how much and what type of plastics are carried in the Turitea Stream. Additionally, where does the plastics come from and is the Turitea Stream has more plastic compared to the other main streams in Palmerston North.

In order to answer these questions, this paper will be broken into four parts. First, literature review on global waste issues with plastic pollution in freshwater and cities then the role of citizen science in tackling the environmental issues. Second, this paper will present the findings from the data collection that were collected and found in the streams of the city of Palmerston North. Third, discussion of the findings and recommendations would be given for better management and strategies to tackle the plastic pollution issues.

2.0 Literature review

2.1 Global waste issues

Global waste pollution is a global concern that requires an urgent management as the population of the world is growing. Rapid growing of human population meaning more consumption is required and consequently generated more waste (Hoonwerg et al., 2013; Singh et al., 2014). An increase in population growth and urbanisation leads to the global economy development with the price that caused to intensively consume the resources and consequently release a huge amount of waste to the environment (Singh et al., 2014). In recent report by the World Bank highlighted that it is estimated 2.01 billion tonnes of worlds' cities waste generated in 2016 and is expected to increase to 3.40 billion tonnes by the year of 2050 as things progress under business-as-usual scenario (Kaza et al., 2018). The world waste generation is 0.74 kg per person per day and it is fluctuated widely from 0.11 to 4.54 kg per person per day where these numbers are generally correlated with the increase rates of urbanization and income levels (Kaza et al., 2018). The report also stated that the total quantity of waste generated in low income countries is expected to increase by 2050 where currently high waste generation is produced by the East Asia and the Pacific region with a fastest growing waste production in Sub-Saharan Africa, South Asia and the Middle East North Africa regions (Kaza et al., 2018).

Waste pollution poses detrimental impacts to the environment. It presents various kinds of threats to environment, especially to the wildlife (i.e. entanglement and ingestion) and human health as well as contaminating the atmosphere including water, soil and air (Derraik, 2002; Alam & Ahmade, 2013; Wilcox et al., 2015). Untreated waste pollution contributes to flooding and air pollution and increases risk to public health including respiratory illnesses, diarrhoea and dengue (Alam & Ahmade, 2013). Inappropriate disposal and inadequate waste treatment contribute to the sources of global waste pollution. Most of the waste generated globally reported to be about 37 % is disposed to landfill, 33% is open dumped, 19% goes through recycling and recovery or composting and 11% goes through incineration (Kaza et al., 2018). According to the International Solid Waste Management (ISWA) report suggested that million tonnes of used plastic each year ended up in the ocean as the biggest dumpsite (Velis et al., 2017). This report also supported by Derraik (2002) who suggested that unquestionably plastic products make up the most global ocean litter. Plastic-based products have become significant source of pollution lost into the rivers and ultimately into the marine ecosystem (Xanthos & Walker, 2017; Jambeck et al., 2015). Apart from environmental impacts, waste particularly plastic pollution also has negative economic impact on important sectors like tourism, fisheries, shipping (UNEP, 2009; McIlgorm et al., 2011). The costs for plastic packaging and it's production-associated greenhouse gas emissions have been estimated at USD 40 billion by UNEP as cited in the New Plastic Economy report

(Ellen MacArthur Foundation & UNEP, 2019). The report highlighted global vision of plastic-related products to be innovated and redesigned to achieve a circular economy which would benefit economy, environment and society (Ellen MacArthur Foundation & UNEP, 2019).

2.2 Freshwater Plastic Pollution

Marine environment has become the last destination of all mismanaged land-based pollution. However, it has been identified that plastic pollution can be found in freshwater environment even in remote and pristine areas (Schimdt et al., 2017). Freshwater systems such as rivers, canals, streams are interlinked with marine environment where rivers eventually transport and discharge plastic debris in marine environment (Schmidt et al., 2017). A study by Schmidt et al (2017) suggested that plastic debris both macro-plastics (>5mm) and micro-plastics (<5mm) are positively related to the mismanaged plastic waste (MMPW) generated into the river catchments. It is suggested that large rivers with high population density in the catchments bring an excessively higher portion of MMPW into the ocean i.e. about 88-95% of global plastic debris (Schmidt et al., 2017). Similarly, previous study done by Lebreton et al., 2017 estimated that between 1.15 and 2.41 million tonnes of plastic pollution per year from the rivers into the sea globally. This study suggested that over 74% of the plastic pollution occur between May and October and 67% of the global total pollution coming from Asia's top 20 polluting rivers (Lebreton et al., 2017). This estimation showed by the model of plastic inputs from the rivers into oceans that based on the waste management, population density and hydrological information worldwide (Lebreton et al., 2017). However, these models only based on data estimations from countries which are still linked with numbers of uncertainties due to lack of field measurements that is limiting the understanding of the dynamics of rivers plastic pollution (González-Fernández et al., 2017; Lebreton et al., 2017; Jambeck et al., 2015). There are still scarcity in accurate measurements as well as standardized methodology in quantifying and monitoring plastic debris fluctuations in rivers (Koelmans et al., 2017; Lebreton et al., 2017; Lahens et al., 2018). In response, a study by van Emmerik and associates (2019) on rivers transport of plastic waste into ocean using an applied spatiotemporal variation in riverine plastic transport in river Seine, France (van Emmerik et al., 2019). By applying spatiotemporal variation in rivers plastic transport, the study demonstrated that during the period of higher discharge tend to increase the plastic transport up to a factor ten at the nearest river-mouth observation point (van Emmerik et al., 2019). This finding suggested that the Seine river plastic debris emissions into the sea tend to substantially higher during increase river discharge (van Emmerik et al., 2019). In addition, this study by van Emmerik et al. (2019) suggested to contribute to the long-term monitoring efforts and plastic pollution mitigation strategies with additional seasonal variation in riverine plastic debris transport (van Emmerik et al., 2019). For instance, freshwater system such as rivers and streams are susceptible to waste plastic pollution. Similar study applied in Seine River, France was also applied to estimate the plastic debris pollution from the Saigon River, Vietnam (van Emmerik et al., 2018). The study found that the macro-plastic emissions from the Saigon River are up to four times higher than previously estimated using hourly cross-sectional profiles of plastic transport made across the river width (van Emmerik et al., 2018). In addition, some plastic pollution that originates from rivers also end up being accumulated in estuaries. A study investigated the seasonal variation of plastic pollution accumulation in the estuary of Wonorejo River in Surabaya, Indonesia (Kurniawan & Imron, 2019). The findings suggested that polyethylene accumulated in the seashore of Madura Strait on the estuaries was significantly higher during rainy season compared to the dry season (Kurniawan & Imron, 2019). All waste and plastic pollution often transport via rivers or streams end up in the ocean have great impact to the freshwater and marine ecosystem.

2.3 Cities' Waste & Plastic issues – New Zealand and Palmerston North case

It is evident that urbanisation and population correlated to the amount of waste particularly plastic pollution generated and lost in the freshwater ways. Previous studies suggested that rivers pollution increase with higher population density where river transport discharge into the ocean (Lebreton et al., 2017; Schmidt et al., 2017).

In the case of New Zealand, waste pollution or plastic pollution issues has not been properly examined. There are not many research study on rivers or stream plastic pollution in comparison to study of plastic pollution in the coastal or marine environment. One of the studies is a study conducted by research scientist at NIWA (National Institute of Water and Atmospheric Research Limited), Dr. Amanda Valois on the plastic pollution processes in rivers. The project study aims to understand the sources and distribution of plastic pollution that are carried by urban rivers with the case study of Kaiwharawhara stream in Wellington (NIWA, 2019). By understanding this case study would assist and improve knowledge of plastic pollution sources and pathway and to identify key locations and seasons of plastic release to the environment (NIWA, 2019). The study also incorporate active community involvement as the crucial component in freshwater restoration project around New Zealand (NIWA, 2019). This monitoring program involved existing community on plastic pollution which also provide them with education improvements, long-term advantages of capacity building and research outcomes that aid in local decision-making (NIWA, 2019).

Similar study on plastic pollution in freshwater streams was done in the largest city of New Zealand, Auckland. The study conducted sampling of microplastic pollution in 21 sites of 18 streams in and around the city of Auckland (Dikareva and Simon, 2019). Although the study found that there was no correlation between population density or combined stormwater overflows with microplastic abundance, but the residential land cover was related to microplastic abundance with low explanatory power (Dikareva & Simon, 2019). It was found that various microplastic abundance was high across the streams (Dikareva & Simon, 2019).

New Zealand's waste issues have been impeded by crucial data deficiencies. It is necessary to further examine the environmental performance of waste management which has been described as dysfunction and delay which poses significant cost to environmental and societal damage in the international status (Hannon, 2018; Hannon & Zaman, 2018). The World Bank data suggested that New Zealand is one country amongst most wasteful developed countries in the OECD, per capita (Hoonwerg & Bhada-Tata, 2012). It has been an increase in the quantity of net waste disposed of in waste levied landfills by 20.1% since the 2014 levy review (Ministry for the Environment, 2017a). Annually, New Zealanders produce about 734 kg of levied waste per person with only 11 % of levied landfills handling 30% of the total waste (Ministry for the Environment, 2017b). The sparse government policy and waste management performance has been inefficient and considered to be slow transitioned to meet the environmental, economic and social benefits on focus of zero waste and circular economy (Hannon & Zaman, 2018; Blumthardt, 2018). In Palmerston North City, the city council has its local waste management programs to address the waste issue. The PNCC's (Palmerston North City Council) Waste Management and Minimisation Plan 2013 targeted the reduction of waste amount end up in landfill. However, there are barriers to achieve the PNCC's waste management goals as there are needs for more wide range of recycling options and kerbside collections (Farrelly & Tucker, 2014). In 2017, the Palmerston North City has been diverted 28,000 tonnes of waste but over 45,000 tonnes of waste still enter the landfills (PNCC, 2019). This means that there are lots of recycling could be done before send over the waste to landfills. In regards to plastic waste, especially plastic bags and single-use plastics have been increased in awareness and petitions to government to ban single-use plastics and related items (PNCC, 2019). With large amount of rubbish still go into the landfills, chances of lost or mismanaged as well as littering are still high which could affect the environment particularly the Manawatu River. The Manawatu River would be one of the sources that eventually transporting the plastic debris into the ocean.

2.4. Citizen science project

As part of this research's goal, citizen science is designed to enable engagement with wide range of community and stakeholders for long-term initiative. Citizen science is described as a form of research collaboration with public in scientific research project to tackle real-world issues (Wiggins & Crowston, 2011). It is a focus on an open participation in research tasks with collective goals that essentially design to manage effective projects (Wiggins & Crowston, 2011). An increase in number of participants involved would increase the number of projects for research and education (Roetman & Daniels, 2011).

Furthermore, well-designed citizen science methodology will increase potential for data collection and analysis which will result in positive impacts such as improving an understanding of the projects on people that become the synergies between research, education and community engagement (Roetman & Daniels, 2011). Moreover, participation of volunteers and their involvement as citizen science in research has increased the scale of ecological field studies and benefit in understanding the processes occurring at broad geographic scales (Dickinson et al., 2010). Centralized-monitoring, more localized and hypothesis-driven research are complements that can be viewed through citizen science benefit (Dickinson et al., 2010). However, it is also argued that although citizen science produces large datasets, it has potential for bias and error which sometimes poorly understood in complicated mechanisms in underlying ecological patterns (Dickinson et al., 2010). Peters et al. (2015) also supported this with the survey on citizen science projects involving community to collect environmental data where data quality and lack of institutional systems are apprehensive. Nevertheless, outcomes of increase in environmental knowledge and relationship-building with stakeholders/groups are proposed with innovative solutions to enhance collaborations in order to produce useful and valuable data with attributed to citizen scientists' efforts (Peters et al., 2015). In addition, advanced technology has been assisted the citizen science project. Citizen science can be empowered with the application of HCI (Human-Computer Interaction) methods (Preece, 2016; Kim et al., 2011). Using application of HCI researchers can empower citizen scientists' skills and accelerate in learning which can increase the project like conservation and educate public regarding specific issue (Preece, 2016). Similarly, citizen scientists who utilize the HCI methods ensure the data is useful for instance, an iphone application Creek Watch allowing volunteers to report information about waterways in order to aid water management program. As a result, the application of HCI methods assisted in design the data for the end users as well as using in designing the user interface (Kim et al., 2011).

Citizen science are active participants involve in environmental projects to collect data and perform research-related tasks which then analysed by the research scientists. It is also a cost-effective way to gather data over wide-range geographical area at the same time raising public awareness (Rambonnet et al., 2019). In New Zealand, there are number of citizen science projects organized by government and non-government organisations. For instance, the Forest and Bird regularly recruit volunteers to count birds and monitor pest traps to assist conservation programmes (Forest & Bird, 2018). Another citizen science project is community-based water monitoring (CBWM) in New Zealand. This is a volunteer monitoring project to help the development of the Stream Health Monitoring and Assessment Kit (SHMAK) and the Wai Care community initiative (Valoís et al., 2019). This project enlisted volunteers and equipped them with improved tools and support systems to assess water quality and suitability for swimming as well as riparian rehabilitation benefits (Valoís et al., 2019). Citizen science approach also has been taking part of living labs project in Palmerston North which is a collaborative research and innovation space between researchers and external partners to co-create new knowledge and practices to address world challenges (Hannon et al., 2019).

PPPC (Palmy's Plastic Pollution Challenge) is a project has been designed as citizen science project to establish scientific baseline data which can support the development of a community based Palmerston North City urban plastic pollution mitigation strategy. This is a partnership between Massey's Zero Waste Academy and Manawatu River to Sea as well as close collaboration with local Iwi, PNCC (Palmerston North City Council) and other relevant stakeholders (Hannon et al., 2019). This PPPC project aims to integrate support the ongoing formal 'waste management and minimisation plan' and other community based environmental programs (Hannon et al.,, 2019).

3.0 Methodology

The methodology adopted from Palmy's Plastic Pollution Challenge (PPPC) methods that has been developed through literature review around urban plastic pollution to fit the PPPC project. The iteration of methodology for PPPC's plastic pollution category model has been proved to meet the purpose for the urban stream/stormwater environment. The data collection started with web-based and desktop practice to identify the potential sample sites in Palmerston North City's streams. To complete the urban streams or stormwater sample sites in Palmerston North City, the additional sample sites from other side of Manawatu River, through Massey University area i.e. the Turitea Stream and alongside Kahuterawa streams complemented the previous city side of Manawatu River i.e. Mangaone and Kawau streams as well as Pioneer and Napier drains. Turitea Stream originates from the The Turitea in the northern end of the Tararua ranges. The Turitea upper catchment serves as main source for Palmerston North's water supply and the Turitea Stream flows through Massey farmland. All activities upstream that affected the water quality usually measured at the lower point at Turitea Stream mouth (LAWA, 2019). Turitea Stream stretches along the area of Bledisloe Park and the Massey University farms. This allows access to the park and walkway paths along the Turitea Stream.

The survey sites were generated randomly using number generator in Excel spreadsheet for a potential data site allocated to Turitea Stream and Kahuterawa Stream. The sites were chosen depending on the distance between bridges which could allocate one or more data collection sites to larger streams. A total of 7 sites and 1 bridges were sampled for rubbish data collection (*see figure 1*). The data collection process followed all procedures that developed for PPPC where on-the-ground assessment was conducted to establish potential suitable data collection sites that meet criteria for accessibility, depth of stream, potential hazards as well as health and safety. Sites were categorized based on its difficulties such as easy, medium or difficult. From the pre-assessment survey, the potential sites were not accessible for large groups and difficult to do the data collection and on its stream depth assessment was done by two data collectors, Dr. Heike Schiele and myself. The data collection sampled area of $100m^2$ that were randomly selected from sections of the stream near the access point of bridge or walkways. The survey used 10m from the point bridge or walkways and start measuring the random number using google maps measurement with three random numbers. The samples were collected from upstream to downstream and collect all pieces of plastic litter (plastics > 1mm). The rubbish were washed, sorted out, weighed and counted pieces. The data were then entered into the database and analyzed.

Figure 1. Measuring $100m^2$ to do the data collection in Kahuterawa Stream [Image by Arsenia da Cruz, 2019].

4.0 Results

These are research findings from complementary survey on Turitea and Kahuterawa streams as part of the local 'Palmy's Plastic Pollution Challenge (PPPC) project. A total of 8 sample sites (7 stream sites and 1 bridge) were sampled for the data collection of litter pollution in the Turitea and Kahuterawa Streams (*see figure 2*). From the sample sites, a total rubbish of 79 pieces collected in 5 sites of Turitea Stream and in 2 sites of Kahuterawa Stream. The number of rubbish pieces was lower compared to the previous sample sites (i.e. Mangaone & Kawau Streams, Pioneer Hwy & Napier drains) which was over 11,000 items of litter that were collected. Previous 41 sample sites still carried the largest number of items that responsible for 80% of all rubbish collected with additional sites from Turitea stream and Kahuterawa stream. These sites are highlighted on the chart.

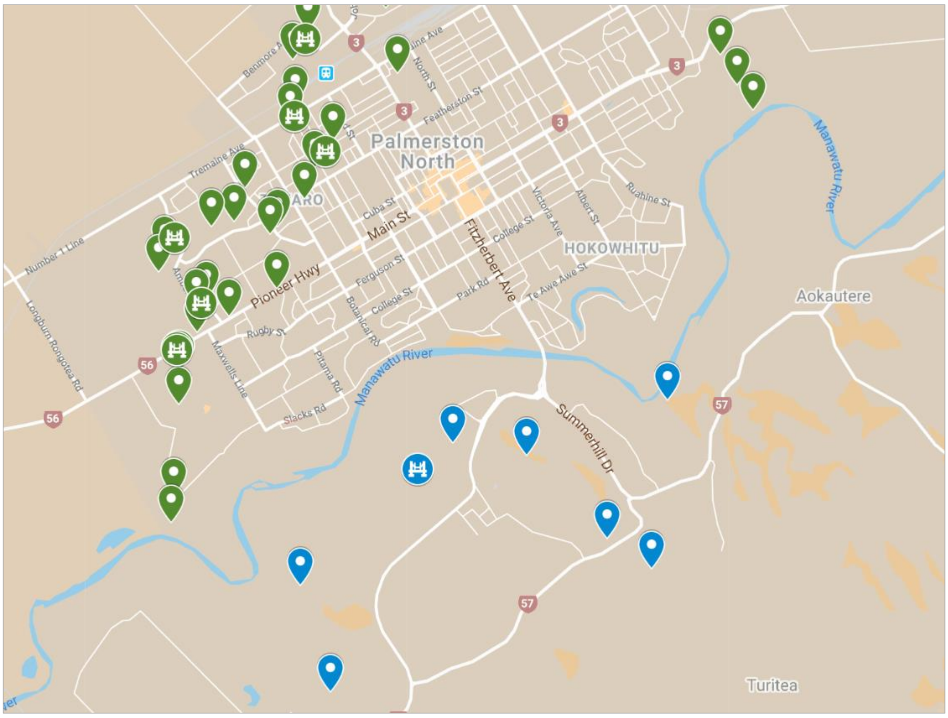

Figure 2. Maps of survey sites (green icons represent previous survey sites; blue icons represent additional Turitea Stream and Kahuterawa Stream)

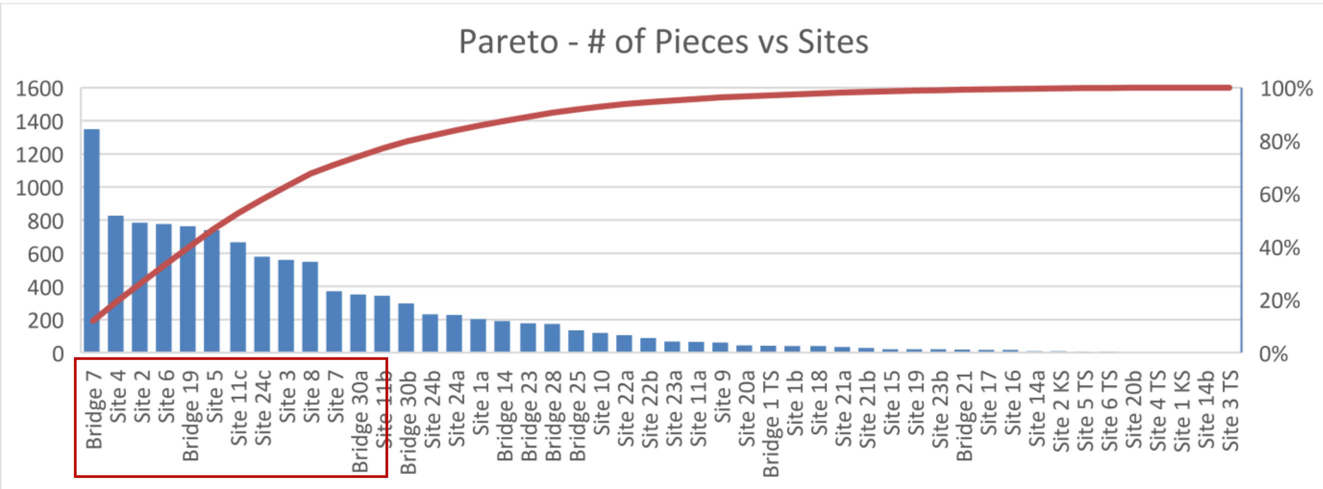

Figure 3. Pareto chart shows sites that had largest number of items of rubbish found in all sample sites in Palmerston North City.

Turitea and Kahuterawa Streams sampling sites had been found to have fewer items compared to previous sample sites. The type of rubbish that found in these sites mostly plastic-based materials with highest 44% (n=35) items. Second highest items found was glass and ceramic pieces with 26% (n=20), followed by metal category with 25% (n=20). The least number of items found was foamed plastic or polystyrene items of 4% (n=3). Other category of litter only consist less than 1% which include clothing, rubber, wood/timber items (*see figure 4*). In contrast, the result showed that metal type material was the heaviest compared to all other rubbish main category in Turitea and Kahuterawa Streams (m=3,065.52g). Second heaviest rubbish was the glass and ceramic pieces (m=1631.61g) and less than 500g weight were rubber and plastics type of rubbish, consisted of 324.24g and 165.23g respectively (*see figure 5*).

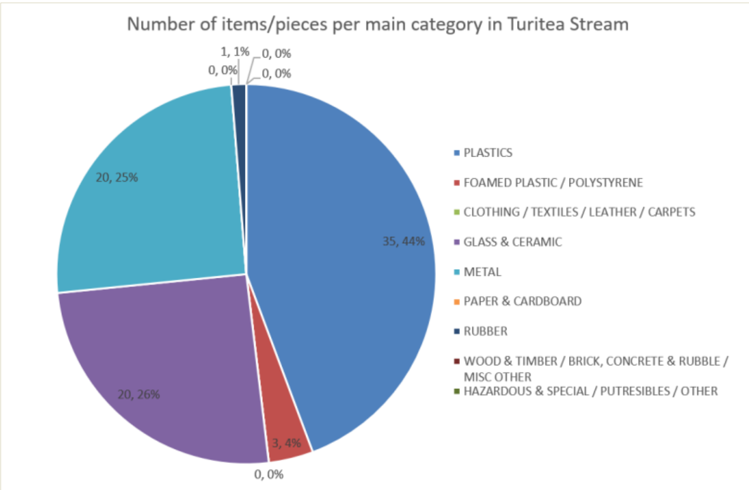

Figure 4. Number of items/pieces per main category in Turitea and Kahuterawa Streams.

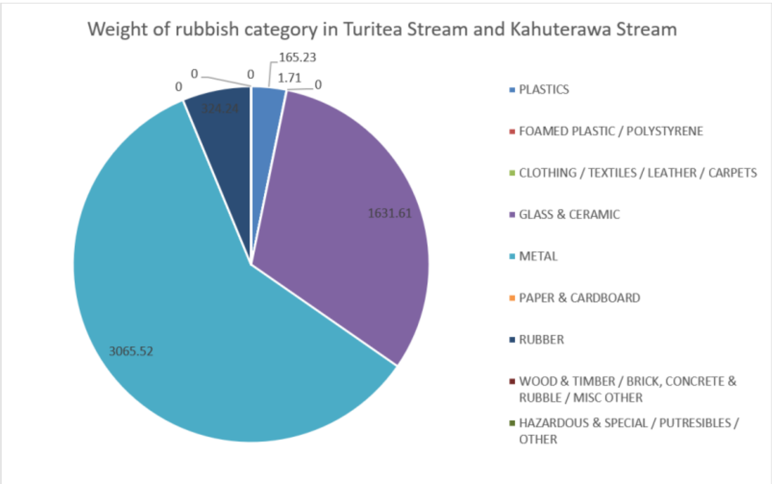

Figure 5. Weight of rubbish found in Turitea and Kahuterawa Streams.

The number of rubbish pieces found in the previous sites were combined with additional data from Turitea and Kahuterawa streams (*see figure 6*). The highest number of items per main category was plastic-products with total pieces of 8139 items, 73% of all rubbish found and collected. Second highest number of items were metal rubbish followed by foamed plastic or polystyrene pieces of 8% with 942 items and 874 items respectively. The third highest items per count were glass & ceramic and paper & cardboard items of 4%, consisted of 472 items and 405 items respectively. Number of items counted less than 2% was clothing or textiles of 231 items and rubber of 101 items which was only 1%. The least number of items found less than zero percentage were the wood & timber, concrete/brick/rubble miscellaneous items (n=39) and the hazardous materials (n=39).

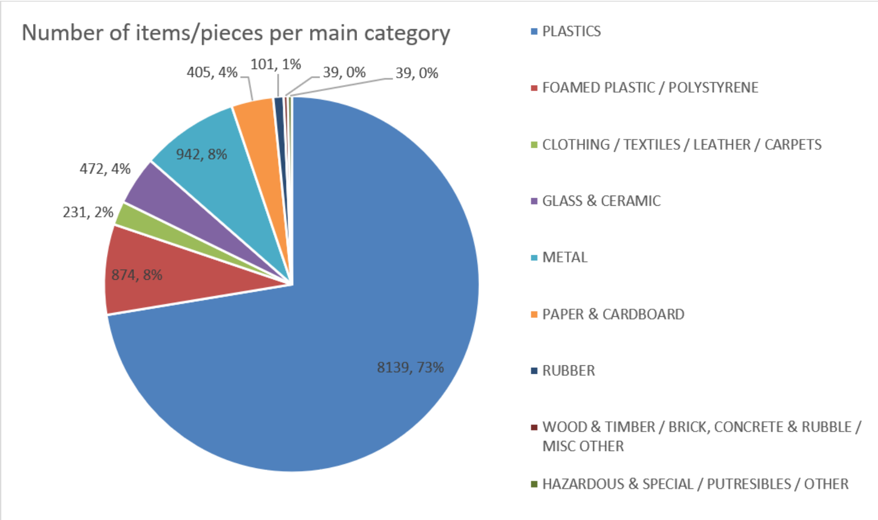

Figure 6. Number of rubbish pieces per main category found in previous sites combined with Turitea and Kahuterawa Streams.

In comparison, the combined weight of all rubbish per main category was found to be based on each type of material. It was found that metal-type rubbish had the heaviest weight per main category (m=150,139.79g). Followed by the rubber material (m=90,049g) and other rubbish main category under 50,000g such as plastics, clothing/textiles, glass & ceramic, hazardous, wood & timber materials (*see figure 7*).

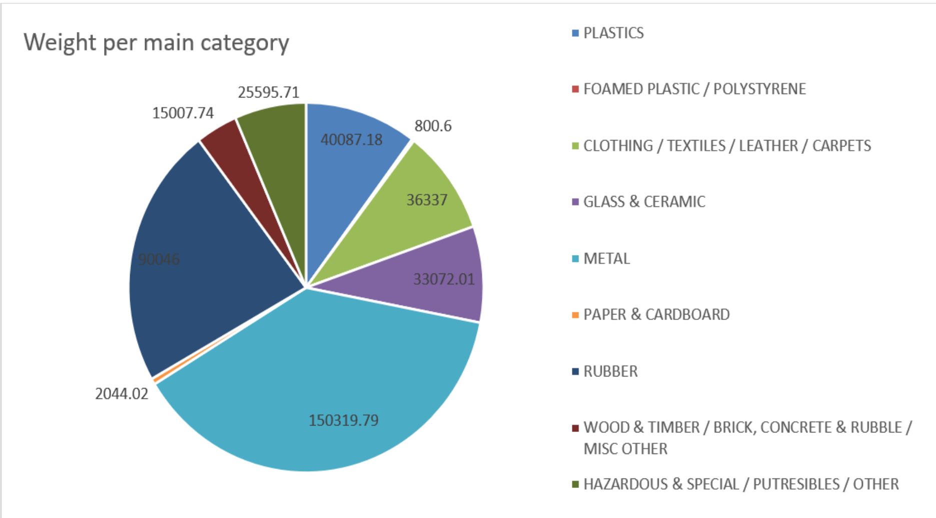

Figure 7. Combined weight of all rubbish collected from Palmerston North City's streams.

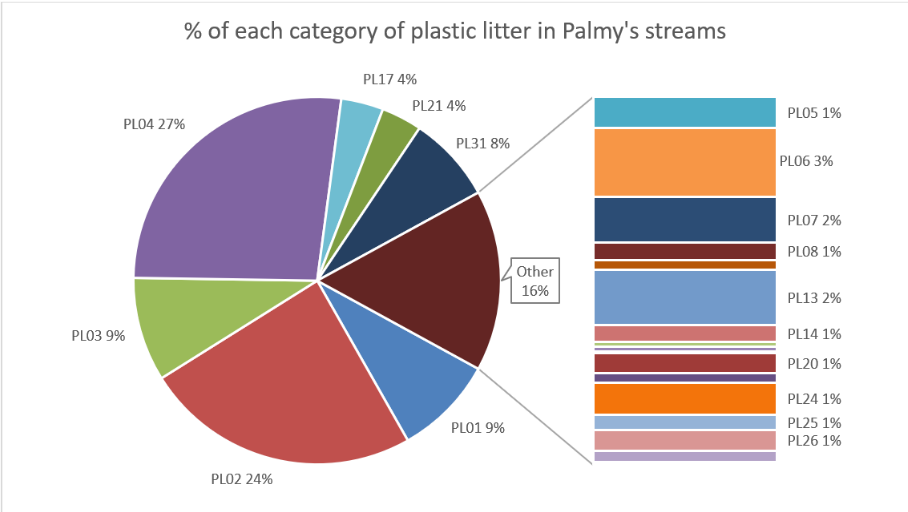

Figure 8. Combined plastic-type materials found in Palmerston North's streams.

Similar findings were found from the combined plastic-based materials that collected from additional streams of Turitea and Kahuterawa Streams. With an addition of 7 sample sites (Turitea and Kahuterawa streams) to previous 41 sample sites, plastic category made up of the most items/pieces found. There were four largest percentage of plastic litter categories distinctively to other plastic categories are following: 1) 27% of PL04: miscellaneous soft plastic; 2) 24% of PL02: food wrappers; 3) 9% of PL03: plastic bags and 4) 9% of PL01: shrink wrap (*see figure 8*).

Figure 9. Miscellaneous soft plastics and other plastic categories with other rubbish found in Turitea and Kahuterawa Streams [Image by Arsenia da Cruz].

It was found that all the combined data from Palmerston North City's streams, plastics pieces that could be recycled consist of 7% (including recyclable and partially recyclable). Figure 10 shows similar percentage of previous data from city's side of Manawatu River and combined data from Turitea and Kahuterawa Streams. There was 93% of non-recyclable plastic items found in the Palmerston North City's streams which means that more reuse and recycle of this plastic products should be encouraged and changes need to be made to redesign for more sustainable products.

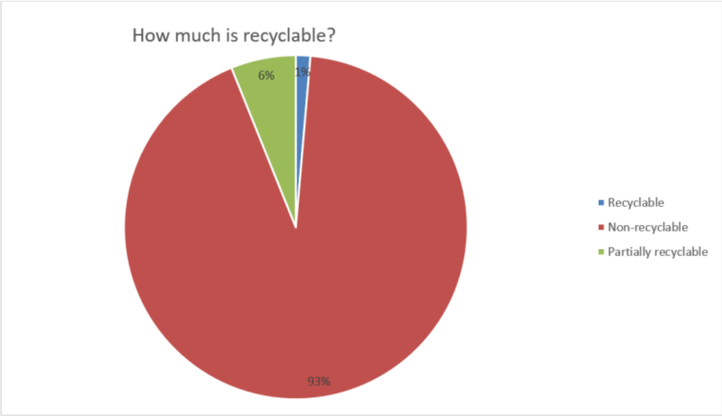

Figure 10. Percentage of recyclable plastic items collected from the Palmerston North City's streams.

The number of rubbish pieces collected in Turitea and Kahuterawa streams were smaller compared to the city side's streams. It was found that the Kahuterawa Stream sites had less rubbish litter compared to Turitea Stream sites. There was one particular stream on the northside of the Turitea Stream (i.e. stream near Pari Reserve) that found to have no rubbish or any human-made litter. There were few large items that found in Turitea Stream but did not get to be collected. These large items were one wheelie bin with lid, a traffic cone, large clothing and parts of a wheel or machinery (*see figure 11*).

Figure 11. Turitea sample sites with large items found but could not be removed [Image by Arsenia da Cruz].

5.0 Discussion

The findings of this complementary data from Turitea and Kahuterawa Streams completed the survey of Palmy's Plastic Pollution Challenge in Palmerston North City's streams. It was clear that the plastic-materials made up the most rubbish type found in the streams by number of pieces. Although only few number of rubbish pieces found in the Turitea and Kahuterawa Streams, but the numbers added up to amount of plastic found previous data. Turitea and Kahuterawa streams were found to have less rubbish compared to other city's stream such as Te Kawau stream catchment which accumulating largest number of rubbish. The two streams had lower litter rates and each site was only found to have less than 20 items (*see figure 3*). Additional sample sites (Turitea Stream and Kahuterawa Streams) located in lower density populated area compared to Kawau Stream and other city's streams which explained lower amount of rubbish found. This can be observed through the buildings, parks and vast farmland that not very accessible to people. The random sample sites were actually located quite distant to crowd. These additional important findings also would assist in understanding the plastic pollution in urban stormwater or streams system and would assist in the development of plastic pollution strategy in the Palmerston North City.

Rivers and streams have been transported rubbish from urban stormwater or catchments into the ocean. However, it is important to find the point of source of the rubbish and prevent them from entering the rivers or streams. For instance, streams that connected to Manawatu River that could avoid pollution in the river ecosystem. The research data collection were done in specific time and selected sample sites where the site details were also assessed. It is also essential to assess the amount of rubbish which based on the spatiotemporal variation and rivers' substrates (van Emmerik et al., 2019; Kurniawan & Imron, 2019). In addition, water level and rivers' discharge could have been used to assess the plastic transport in different seasonal period of the year.

All rubbish pieces collected and counted with a total of more than 80% were categorized as plastics and foamed plastics or polystyrene. This research suggests that the plastics pollution clearly made its way to even remote, inaccessible and pristine areas (Schimdt et al., 2017). This plastic pollution issue is not only local but has become broad national concern. Local community should be aware of the waste pollution crisis and need to understand the importance of better management of plastic waste issues.

Although the additional data collection were done only by the researchers for this project, the citizen scientists still play an important role of monitoring and improving the data collection in the field. It is crucial that citizen science involve many organisations and groups to improve the project outcomes and working together for effective and sustainable management (Dickinson et al., 2010; Peters et al., 2015).

6.0 Conclusion & Recommendations

Waste plastic pollution is a complex issue with no straightforward solution. Though this research project only part of the 'whole city' of Palmy's Plastic Pollution Challenge (PPPC), it serves as additional useful data to the baseline information for the development of plastic pollution strategy. The Turitea and Kahuterawa streams have been found to have most of plastics type of rubbish which suggests that plastics made up most of rubbish in the freshwater ways. Although the amount of rubbish found in the Turitea and Kahuterawa streams were fewer compared to other streams on the city (i.e. Kawau Stream, Mangaone Stream, Pioneer Hwy drain, Napier drain), it completed the survey in Palmerston North City's streams which could help better understanding of how much plastics in the freshwater ways.

There are several recommendations that suggested for future and long-term initiative of the PPPC to tackle plastic pollution issue. First, plastic pollution sampling needs to incorporate more factors which not only quantifying surface debris but also abundance of plastic or other rubbish with depth of water column. The study should also incorporate more spatiotemporal variations and substrate or vegetation types in the sites to enable comparison of different seasonal variation of rivers/streams discharge of plastics. Second, plastic-packaging and shrinkable plastic were found to be the most abundant in the streams. We can only manage what we have measured, therefore, in order to reduce the plastic pollution in the streams, it requires actions on reducing the plastic packaging through increase the reuse of plastic, eco-design plastics to compostable packaging. In order to make this transition, the extended producer responsibility should be encouraged by the government and industries to create new innovation to replace plastic-product packaging. Last, increase in education and public awareness in understanding the importance of waste management. It is important to increase general public awareness with all the information tools available. This could be done with advanced technology that are available including social media, online survey, training and environmental education videos.

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