UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

University Neighbourhoods Association [UNA] Multi Unit Residential Building [MURB] Waste Behavioural Research

Ivana Zelenika, PhD Candidate
Resource Management, Environment and Sustainability (RES 699)
University of British Columbia
October 25, 2017

EXECUTIVE SUMMARY

This project's main aim was to improve waste sorting at UBC University Neighbourhood Association (UNA) multi-family residential buildings (MURBs) by applying low-cost interventions informed by behavioural psychology. With a focus on effective signage and education, we examined strategies that a) increase participation in waste diversion, and b) reduce contamination of waste streams. City of Vancouver, Metro Vancouver and the UBC all have ambitious zero waste goals for 2020 and beyond. However, participation of MURBs is one of the lowest of all the sectors in the region. With the recent Metro bylaw banning organic food in garbage, and the increased emphasis on waste diversion, there is a tremendous opportunity to mobilize more effective residential participation in recycling and composting.

Working with UBC SEEDS program and UNA Sustainability team, four residential buildings were recruited into the study, with a total of 189 residential units. The study took place from June 2015 to April 2016. We had 3 weeks of baseline followed by a series of interventions as follows. First, "Basic Signage", followed by "Food is not Garbage" posters 3 weeks later. Afterwards we introduced the "New Visual signage" in all buildings to help with contamination of streams, which were left over the December and January period for observation. The last intervention was "Door to Door canvass" in February, followed by 3 weeks of Post intervention measurements in March. We examined the effects of interventions on participation and contamination in recycling and composting program. Participation was measured as kg of material (and subtracted from weight of empty bins), while contamination was visually observed and counted as total number of items that should not be in the bin.

All of the buildings' data of kilograms collected and contamination was merged for collective analysis. The descriptive and statistical results show that recycling signage from UBC and waste hauler websites, and especially the newly designed visual posters, reduced contamination in compost and recyclable container bins, although without statistical significance. Door to door canvass was especially effective at reducing compost and recycling contamination, with statistical significance. "Food is not Garbage" posters were very effective in bringing out participation and increased the weight of compost bins with statistical significance. However, with participation came an increase in contamination of the green bins, which was somewhat reduced through new visual posters and the door to door canvass. We found that none of the interventions had a significant impact on the weight nor the contamination of mixed paper products.

Our study shows that visually useful signage, as well as door to door interaction with residents can help reduce contamination of recycling and organics bins in MURBS, while increasing participation for organics and recyclable container streams. However, contamination of waste streams was not eliminated and ongoing attention is needed. This includes improvements in convenience and infrastructure (recycling room and in-suite), signage and communication to motivate and educate residents. Future research should test our results with a control building and post-intervention periods between interventions to better validate results. See Conclusion chapter for detailed discussion of results, limitations and stakeholder recommendations.

ACKNOWLEDGEMENT

The author would like to thank the following for help during this research:

- AMS Sustainability Projects Fund for generous financial support for project supplies, scales and signage printing costs.
- Liska Richer (SEEDS) for guidance and help in all aspects of the project.
- Dr. Jiaying Zhao (IRES/Psychology) for critical feedback and design of the study.
- Wegland Sit (UNA Sustainability) for facilitating the introductions, recruitment of buildings, and useful feedback throughout the project.
- Laura Cottle, Linda Quamme, Ian Young & Cheryl Taunton: Thank you for being the recycling champions in your community and enrolling your buildings in the study! Thank you for arranging the building access and for feedback throughout the project.
- Bud Fraser (UBC Sustainability and Engineering) for useful insights and helpful comments.

TABLE OF CONTENTS

INTRODUCTION

More than half of the world population lives in cities consuming 80% of all energy and emitting 70% of all global greenhouse gases[1]. With urban population expected to rise in the coming decades, communities must actively work to develop pathways toward a more sustainable future. Effective waste management is a crucial part of the sustainability agenda, with a goal to recover recyclable and compostable materials and reduce the number of items sent to landfills. Both UBC and Metro Vancouver have ambitious zero waste goals, with the recent organics bylaw (no food in garbage) providing a strong policy support. Vancouver's Greenest City Action plan has set the waste diversion target for the region at 80% by 2021, with a 50% reduction of solid waste going to incineration or landfill from 2008 levels[2]. UBC and the University Neighbourhood Association (UNA) are aspiring for the similar diversion goals to match Vancouver's targets[3]. UBC currently diverts about 67% of all waste[4]. UNA is a vibrant self-governed community within UBC that houses over 8,000 students, staff and faculty providing municipal-like services for residents. However, the multi-family residential buildings (MURBs) all throughout the region have one of the lowest recycling participation rates of all sectors. Unlike in single family homes where a lack of a blue or green bin for weekly collection signals non-compliance, in MURBs it can be much harder to target and motivate residents that do not recycle since it is not always possible to identify and reach them. As such, there is a tremendous reseach opportunity to stury and mobilize MURB residents to participate in recycling and composting, and do so correctly.

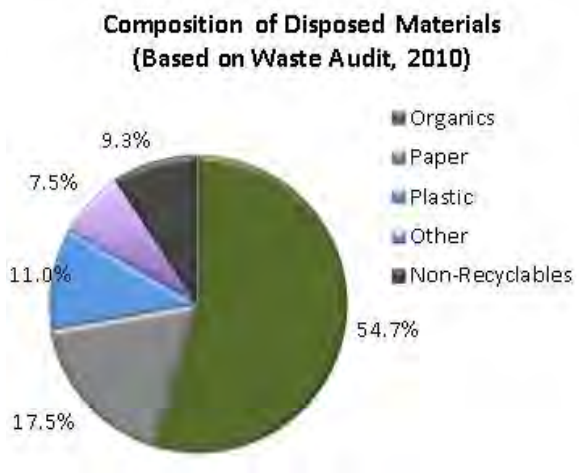


Figure 1. Composition of UBC consumer waste from 2010: About 90% of daily waste can either be recycled or composted, with majority of waste consisting of organic matter.

[1] World Bank, (2010). Part III: Cities' Contribution to Climate Change, in Cities and Climate Change: An Urgent Agenda. Volume 10. Washington DC: The International Bank of Reconstruction and Development. The World Bank.
[2] City of Vancouver, (2017). Greenest City Action Plan, Goals and Targets: Zero Waste. Available at: http://vancouver.ca/green-vancouver/zero-waste.aspx
[3] UBC Zero Waste Action Plan, (2013). Campus and Community Planning, Campus Sustainability.
[4] UBC (2016). Annual Sustainability Report, 2015-2016.

Successful waste sorting involves two key elements: i) **participation** (motivating residents to use recycling and compost bins), and ii) **accuracy** (avoiding contamination of waste streams). Incorrect sorting leads to critical contamination of the waste streams which results in all the bin's contents going to the landfill, cancelling out the positive intent of participation.

Knowledge of what goes into which bin and what doesn't is a crucial component of waste sorting not only because it affects contamination of bins, but also people's self-efficacy and confidence which can further affect willingness to engage in the behaviour. For example, surveys by UBC Communications and Marketing team revealed that while 75% of students, staff and faculty believe recycling and composting is a right thing to do, they recycle mostly when it's convenient, and claim they require better infrastructure and more information on what goes where[5]. If people don't perceive they can do the behaviour (due to lack of knowledge, experience or infrastructure), they are less likely to engage with it, and do so correctly. As communities take up composting due to the ban on organics in garbage there is a surge of participants in the green bin program. However, if bins are contaminated past threshold (~4-6% of the bin, or depending on the type of contamination), then all contents are sent to the landfill cancelling out the positive intentions of participation. Currently, contamination of compost bins with non-compostable and plastic shopping bags (and other plastic contaminants like cutlery and soup lids) is a growing concern for UBC and Metro region.

However, getting the right information and educating people on recycling dos and don'ts can be very difficult due to the time-consuming efforts and resources required to reach and inform all residents. Furthermore, environmental and behavioral psychology research has demonstrated that human attention is a valuable resource, as there are limits to people's ability to detect, process and commit information to memory[6]. Variety of mixed materials in the marketplace, inevitable and frequent changes to the system, and differences in what's accepted between regions all add to confusion of residents when trying to sort waste. Due to these and other barriers, sorting knowledge gaps exacerbate problems even when recycling attitudes are strong.

Given the need for better waste diversion in MURBs, this project is aimed to improve waste sorting at UNA by applying interdisciplinary strategies informed by psychology and community based social marketing. They point out that the most effective information provision campaigns should involve simple, salient, visual and personally relevant information as opposed to technical, or comprehensive ones [7]. Other waste studies have also stressed the priming effects building infrastructure can play[8] with social and situational norms, including the convenience and distance to bins[9]. Although infrastructural changes were not the primary focus of this study, observations were made on the physical elements of the buildings, with the main goal of providing effective signage and education.

---

[5] UBC Communications and Marketing, (2014) Recycling and Composting Attitudes and Behaviours. Report prepared by John Lo.

[6] Kahneman, D. (2011). Thinking, Fast and Slow. Farrar, Straus and Giroux.

[7] Mckenzie-Mohr, D. (2008). Fostering Sustainable Behaviour: Beyond Brochures. International Journal of Sustainability Communication, 108–118.

[8] Wu, D. W. L., DiGiacomo, A., & Kingstone, A. (2013). A Sustainable Building Promotes Pro-Environmental Behavior: An Observational Study on Food Disposal. PLoS ONE, 8(1), 1–4

[9] DiGiacomo, A., Wu, D. W.-L., Lenkic, P., Fraser, B., Zhao, J., & Kingstone, A. (2017). Convenience improves composting and recycling rates in high-density residential buildings. Journal of Environmental Planning and Management, 1–23

METHODS

PARTICIPANTS

This field experiment was conducted in 4 multi-unit residential buildings (MURB) located on the UBC campus, which are part of the University Neighborhood Association (UNA). UNA is a vibrant and growing self-governed community that houses over 8,000 students, staff and faculty providing municipal-like services for residents. Facilitated by the UBC's SEEDS program and the UNA Sustainability team, four buildings were recruited to the research project in summer of 2015. While buildings differ in size, layout and waste haulers, they have a similar composition of residents and recycling room infrastructure.

RESEARCH QUESTIONS

- Which type of intervention will increase participation and accuracy of waste sorting in MURBs?
- What type of intervention will have best effect on each of the waste streams: Organics, Containers, Paper and Garbage?

With the goal of education, we decided to deploy and test a series of commonly used interventions, such as improved signage and door to door visits. They represent common low-cost strategies that can be adopted by any community.

Table 1: Details of buildings that participated in the UNA SEEDS Zero Waste study.

Building Name	**Hawthorn Green** 	**Esse** 
Year Built	2004	2005
# of Units	20	31
Waste Contractor	UBC for all services	UBC Organics, Smithrite for all other services
Notes	No elevator, external recycling room.	No elevator, indoor recycling room, but organics bin kept separate from other bins in garage area.

Building Name	Logan Lane 	Reflections 
Year Built	2005	2005
# of Units	61	77
Waste Contractor	UBC Organics, Progressive all other services	Smithrite for all services
Notes	No elevator & two indoor recycling rooms, Paper collected with cardboard and could not be measured.	2 Elevators, 1 indoor recycling room. Also collect lightbulbs and plastic bags.

PROCEDURES AND MEASURES

Participation = Weight (kg) of material

Participation and accuracy of sorting was measured every week, a day before the collection of a waste stream. The bins were measured on a portable DYMO® S250 Digital USB Shipping Scale. Participation was represented through weight of recyclable and compostable materials, with weight of an empty bin subtracted from the total kg amount. The protocol involved measuring the weight of all non-garbage bins: food scraps/organics, recyclable containers and paper, and in some instances the yellow Return-It bins used for deposit items. Due to the large size of garbage and cardboard vessels it was not possible to measure and include them in this study. One building (Logan Lane) collects paper and cardboard together so we were not able to gather paper data for this building.

Contamination = Number of incorrectly sorted items per bin

Contamination was calculated through a visual identification check and counting all items that should not be in that bin in a sanitary and safe fashion using gloves and tongs. Due to the depth of some large waste bins and the packing nature of organic material, it was not always possible to thoroughly inspect all bins for contamination. When recycling bins are mostly full, material at bottom was not possible to reach and visually inspect. For compost bins this number is even higher at about 50%. This study did not include the garbage stream due to the size and weight of the garbage receptacles and safety concerns. This would have helped deduce true waste diversion per building. Only compost, recycling containers, and paper bins were measured and analyzed. Bin dimensions across all buildings were in the range of 22 x 24 x 40 and 25 x 30 x 40 inches.

INTERVENTION CONDITIONS

This study had no control and all four buildings participated in all interventions. After a 3-week baseline and a short pilot, all buildings joined the study in September 2015. The first intervention involved receiving basic signage inside recycling rooms, followed by "Food Isn't Garbage" composting posters. We further improved the visual features of the signage posters and conducted a door to door canvass. Interventions ran until March 2016 with post-intervention measurements concluding the study.

Table 2. Study Intervention Schedule

Timeline	Type of Intervention
June – August 2015	Sorting Game Pilot in Hawthorn
Sept 14, 2015	Start of Baseline in all buildings
Oct 5, 2015	Basic signage
Oct 26, 2015	"Food Isn't Garbage" posters
Nov 11, 2016	New visual signage in all buildings
Feb 29, 2016	Door to Door canvass (Hawthorn and Logan)
March 6 – 27, 2016	Post intervention measurements

IMPROVED SIGNAGE INSIDE RECYCLING ROOMS

Since several buildings had insufficient or missing signage in the recycling room, the first intervention was to improve signage across all buildings. Posters were obtained from the waste haulers and UBC campus sustainability websites (Appendix B) and printed out.

Figure 2: An example of no signage at baseline and "Basic Signage" intervention in Hawthorn Lane.

FOOD ISN'T GARBAGE POSTERS

Both Metro Vancouver and City of Vancouver passed a bylaw ban in 2015 on organics in garbage (i.e. food scraps and other compostable materials). Since then, UBC and UNA have rolled out the green bin program in every building. The organics programs often suffer low participation due to the 'yuck factor' brought on by assumptions and fears of smells and fruitiest, as well as the cost and availability of countertop bin containers and bin liners. To help entice motivation in the program we decided to use Metro's food scraps campaign posters to draw attention and spread the injunctive message that food leftovers do not belong in garbage. Downloadable posters and social media are available on Metro website.[10]

Figure 3: "Food Isn't Garbage" posters designed by Metro Vancouver put up on all recycling room doors and the elevators in study buildings.

[10] Downloadable posters and social media images from Metro Vancouver: http://www.metrovancouver.org/services/solid-waste/recycling-signage-campaigns/campaign-posters-artwork/Pages/default.aspx

NEW VISUAL RECYCLING SIGNS

Realizing that the basic signage might be insufficient (small print, too many items) our team set pout to improve waste signage. Inspired by the UBC psychology's Brain and Attention Research Lab work on signage which showed that colored 3D icons help with sorting accuracy, a second version of posters called "New Visual Signage" was designed. The goal of new signage was to reduce thinking and confusion while focusing on several key contamination issues. The poster's main features are bright colors to draw attention, clear images and distinction of what is allowed and what is not, and focusing on the six most common household contaminants. Signage for all four waste streams were placed above the bins, with garbage / landfill placed above the dumpsters. A copy of all 4 waste stream posters can be found in Appendix C.

Figure 4: An example of the New Visual Signage put up in all the buildings.

DOOR TO DOOR CANVASS

The last intervention was a door to door canvassing visit. The main purpose was to interact with residents face to face, remind them to participate in the waste diversion and answer any questions they may have. The visit also served as an opportunity to inform residents about recycling services available at the UNA Green Depot where they can recycle e-waste, batteries, lightbulbs and plastic bags. We also advertised the online Sorting Game for residents to play, which teaches participants how to sort through instant feedback.

Two buildings participated in door to door canvass (Hawthorn and Logan Lane) and results were compared to the remaining two buildings which served as a control.

Figure 6: Canvassing pamphlet handed out during the Door to Door visit (page 1 and page 2).

RESEARCH RESULTS

PILOT: THE ONLINE SORTING GAME

Prior to September study roll out, a short pilot was held at Hawthorn Green from June to August to establish measurement procedures, and test out the online sorting game developed by Yu Luo for the Zhao Behavioral Sustainability Lab[11]. The game provides a real-time feedback when a player gets the item right or wrong, teaching participants how to sort. Posters inviting residents to play the game (and enter to win a grocery gift card) were placed at the recycling room door and were also handed out to each resident. A copy of the poster can be seen in Appendix A. Unfortunately, while most residents likely saw the posters only 1 household finished the full 40 items game. Therefore, we cannot ascertain the effectiveness of the sorting game. The descriptive waste data showed some improvement in weight and accuracy (contamination per kg) for organics and containers bins over 3 weeks of baseline followed by 3 weeks of post intervention measurements. Paper bin ratio during baseline and game intervention remained unchanged. The game pilot provided valuable insights into difficulty of motivating residents to play the game, and the need to reduce the number of items in the game. The game is still online and active, and can be used as an engagement and education tool by accessing and sharing the link: http://yuluo.psych.ubc.ca/studies/Sorting_MD/ .

IMPACT OF INTERVENTIONS ON ORGANICS / COMPOST

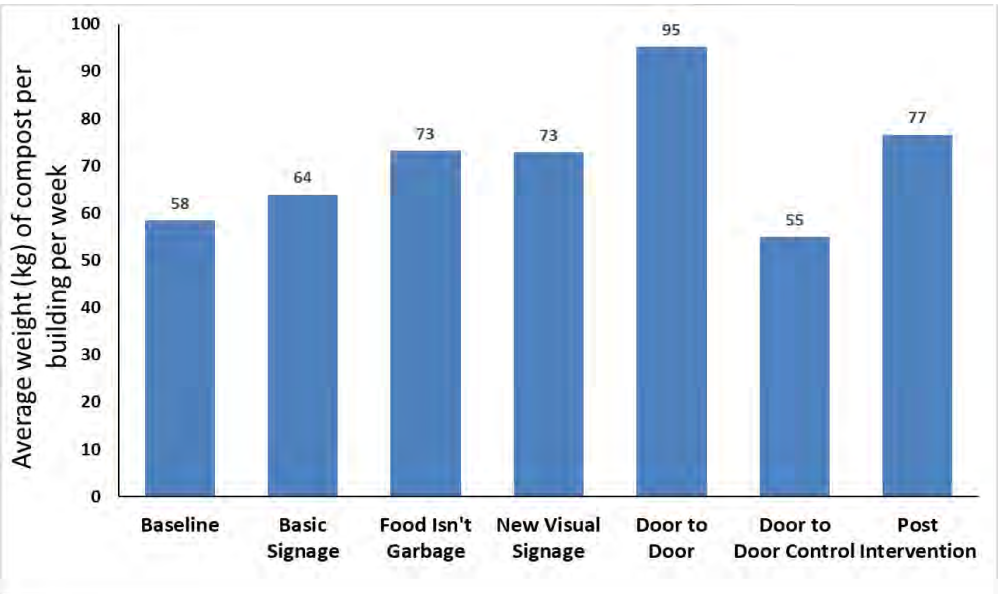


Figure 7: Average kg of Organics per building per week for all buildings combined.

[11] http://yuluo.psych.ubc.ca/studies/Sorting_MD/

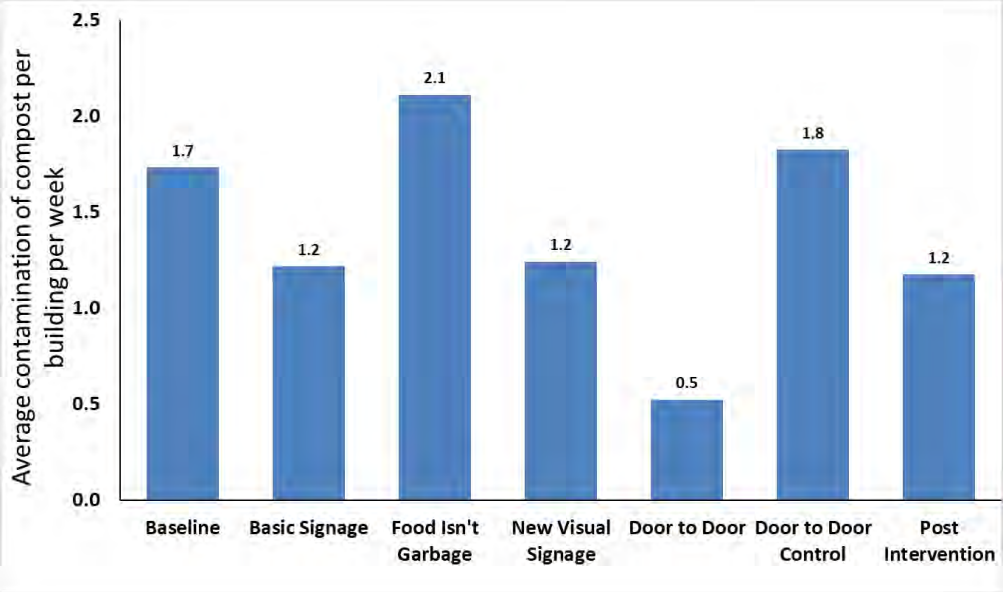


Figure 8: Average contamination of Organics per building per week for all buildings combined.

As Figure 7 shows, weight of compost increased with each intervention. At the start of the research the baseline averaged about 58kg of compost per building per week culminating with 77kg of organic material per building at the end of the project. To better analyze the impact of the interventions, statistical analysis of variance ANOVA was conducted between the buildings and intervention periods across 4 waste streams through R Studio. We found that there was a significant effect of intervention (p<.001), and building (p<.001), but no interaction between intervention and building (p=.37). Tukey's HSD post hoc test showed there was a marginal difference in kg of compost between baseline (58kg) and food isn't garbage as well as new visual signage (73kg) with p=.06. There was also a significant difference between baseline (58kg) and door to door (95kg) with p<.001, as well as between baseline and post intervention period (p=.01). The difference between door to door intervention (95kg) and the door to door control (55kg) was statistically significant with p=.02.

Regarding contamination of the bins (Figure 8), the data showed basic signage reduced contamination at baseline from 1.7 contaminants to 1.2, until Food Isn't Garbage poster was introduced which brought it back up 2.1 contaminants per bin per week. It appears that the Food Isn't Garbage posters prompted residents to participate in the organics program which increased the weight of the bins. However, with participation often comes contamination and so the number of contaminants went up along with the weight. Introduction of the New Visual Signage helped reduce the contamination to 1.2 contaminants, which reduced further with the door to door canvas. ANOVA analysis showed there was an effect of intervention on contamination (p=.01), but not of building (p=.37), and there was an interaction between the intervention and the buildings (p=.02) on the amount of contamination. Tukey's HSD test showed that Food's Not Garbage posters had a marginally negative effect by increasing contamination to 2.1 (p=.09), after which the door to door intervention decreased contamination to .5 contaminants (p=.12).

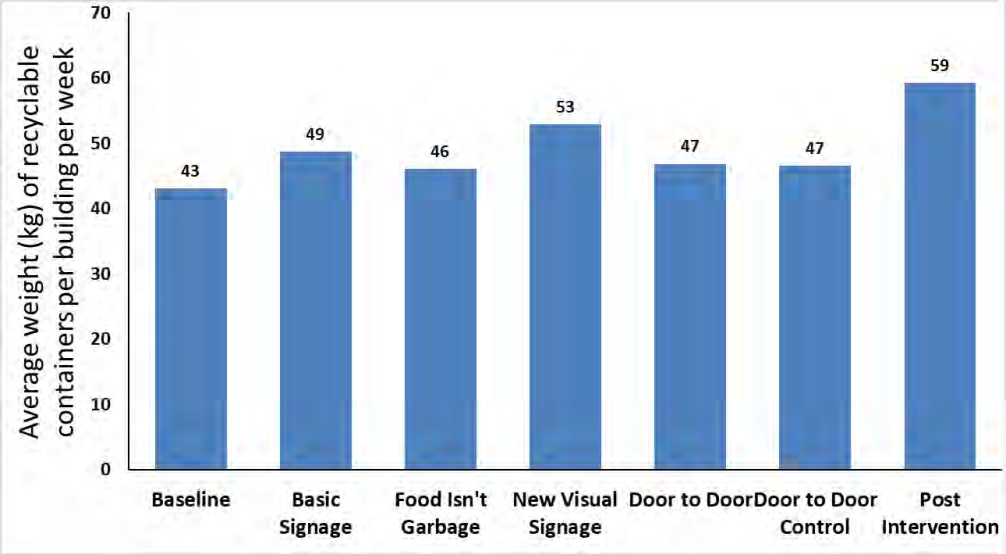


Figure 9: Average weight (kg) of recyclable containers per building per week for all buildings combined.

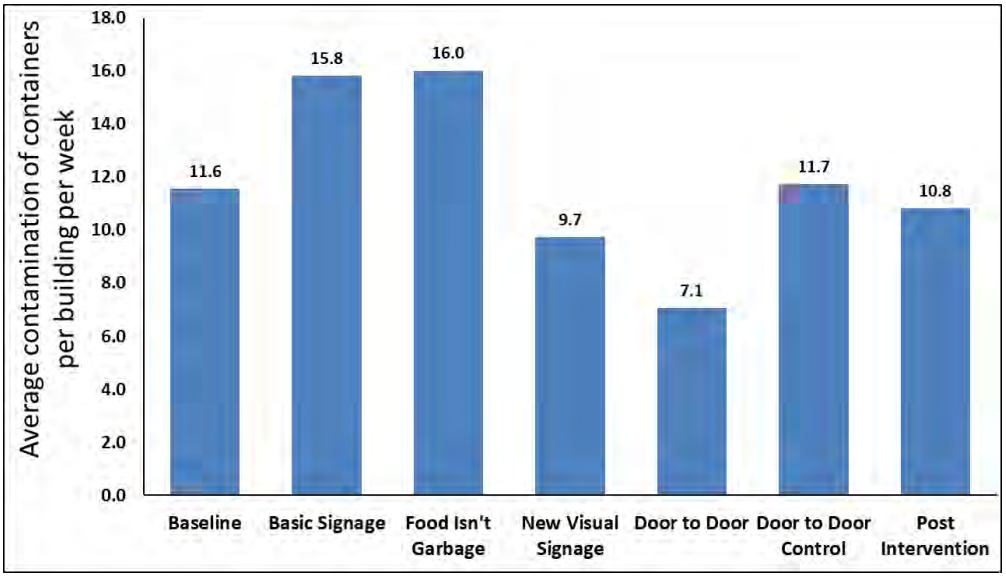


Figure 10: Average contamination of containers per building per week for all buildings combined.

Descriptive data shows that both type of basic and visual signage helped increase the weight of bins from baseline (43kg) to 49 and 53 kg respectively, but the door to door campaign had no impact on the weight of the bins compared to control (47kg). Weight of containers remained high in post-intervention period.

ANOVA analysis showed there was no significant effect of any type of intervention on the kg weight of container bins (p=.46), and there was no interaction between building and intervention (p=.56). Tukey's test found no statistical difference between interventions on the kg of container

bins. Regarding the contamination of containers bins (Figure 10), we found that compared to baseline measurements (11.6 contaminants) basic signage did not help with contamination (15.8) and neither did Food Isn't Garbage poster (16 contaminants). However, the new visual signage (9.7) and door to door (7.1) helped reduce contamination which stayed low in post-intervention period (10.8 contaminants). ANOVA confirmed that there was a main effect of intervention on the contamination of container bins (p=.01), and there was no interaction of building and the intervention with p=.23.

Tukey's tests showed there was a significant difference between basic signage and the effect of the door to door intervention (p=.01), door to door and food's not garbage (p=.02), as well as new improved signage and food's not garbage posters (p<.001).

IMPACT OF INTERVENTIONS ON PAPER BINS

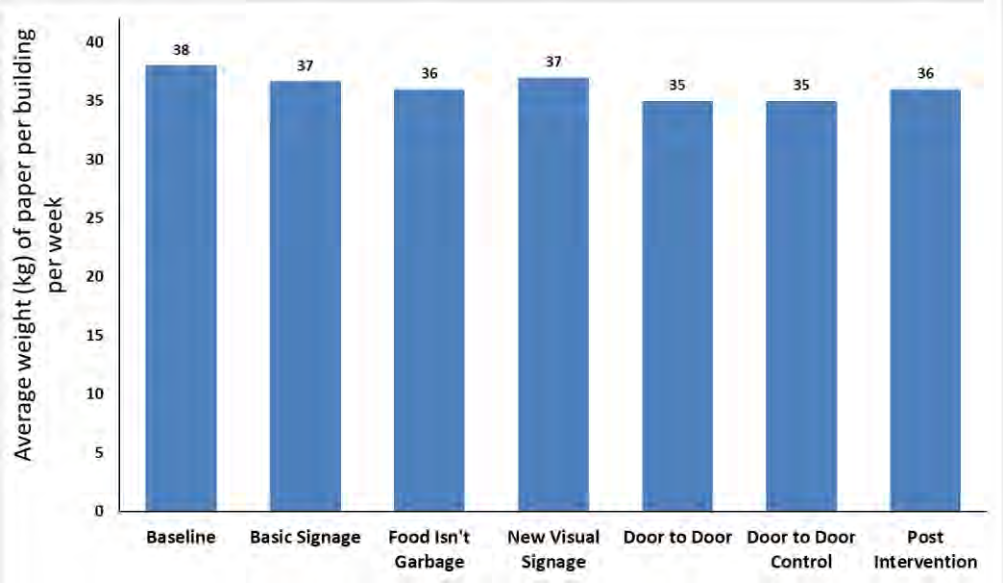


Figure 11: Average weight (kg) of paper per building per week for all buildings combined

Figure 11 shows there was no significant change in weight of paper from the baseline (38kg) to post-intervention period (36kg). ANOVA and Tukey's test found no difference in intervention type on kg of materials, but did found that there were differences between buildings with p<.001. Logan Lane building collects mixed paper with the cardboard receptacle we could not measure due to its size, and this could have enhanced the differences between buildings that may exist anyways.

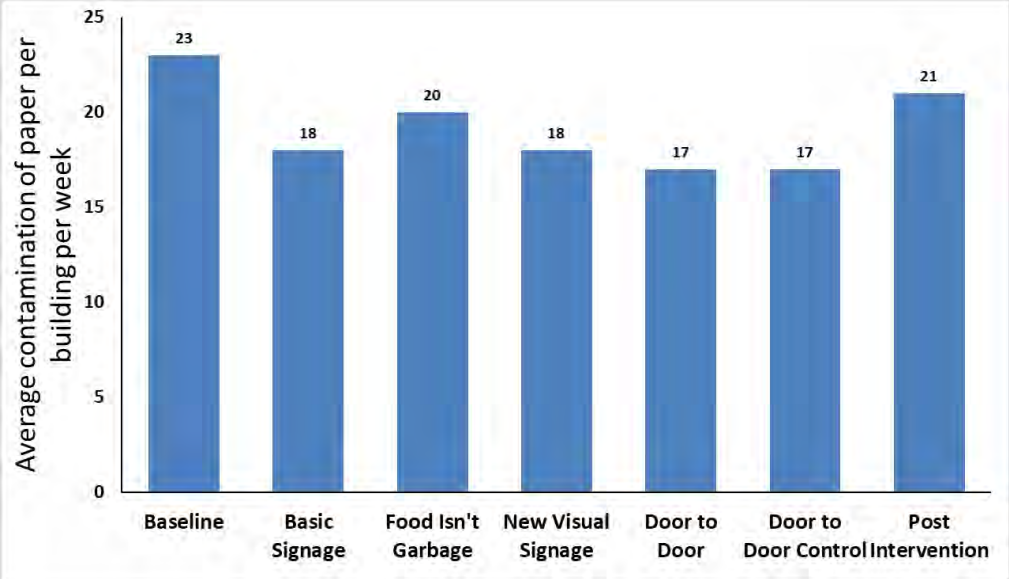


Figure 12: Average contamination of paper per building per week for all buildings combined.

Regarding contamination of paper bins (Figure 12) basic signage helped with reduction of contamination compared to baseline (23 contaminants) with basic signage and visual signage (18 contaminants) and door to door (17) having the same effect with marginal statistical significance. ANOVA however showed the effects of the intervention were not statistically significant (p=.10), and there was no interaction between building and intervention (p=.17).

We saw no difference between door to door and door to door control on paper contamination, which could have been affected by the fact that paper could not be measured in Logan lane. Although contamination of paper went down over the course of the study, there was no statistical difference between baseline and post-intervention period.

CONCLUSION AND RECOMMENDATIONS

The results of this study show that low-cost interventions such as visually useful poster signage and door to door interaction with residents (while providing resources), can help improve weight and contamination of recycling and composting material in multi-family residential buildings (MURBS). We found that standard signage (available from UBC or waste hauler websites), and especially the visual posters, reduced contamination in compost and recyclable container bins, although without statistical significance. Food is not garbage posters were very effective in bringing out participation and increased the weight of compost bins with statistical significance. However, with participation came an increase in contamination of the green bins, which was reduced through new visual posters and the door to door canvass. Door to door canvass was especially effective at reducing compost and recycling contamination, with statistical significance.

DISCUSSION

Organics Stream

Regarding the Organics waste stream, we find that all types of interventions helped increase the weight compared to baseline, with "Food isn't garbage" poster, "New visual signage", and Door to Door having the biggest impact ($p<.001$). Similar effects were noted in contamination of bins, except that "Food is not garbage" posters increased contamination of the bins and needed to be followed up with a way to inform redidents which materials to keep out. This seems to show that interventions that solely focus on the increase of participation can bring with it contamination, if information or know-how is missing. New "visual signage" interevention helped with this goal, although it did not have statistical significance. The difference between buildings that conducted door to door and those that didn't was however statistically significant ($p=.02$). We also received positive feedback from residents about their door to door exeperience. It is important to note that compost bins were very difficult to thouroughly inspect due to the compacting and decomposing nature of organic materials. Therefore, the full contamination data of compost bins in this study are not known. The most common contamination in compost bins were plastic or biodegradable bags, plastic cutlery and non-compostable take out packaging.

Recyclable Containers

For recyclable containers (plastics, cans and glass) we found that both types of signage helped increase the weight of material from the baseline with "New visual signage" having the best effect but without statistical significance ($p=.56$). Although not significant, the weight of recyclable containers remained high in post intervention. Regarding contamination: compared to baseline basic signage and food isn't garbage had a negative impact on contamination, but improved visual signs helped reduce contamination as did the door to door canvas, with statistical significance ($p=.01$). The most common contamination of container bins were plastic bags, styrofoam (from take out containers or shipping products), and non recyclable materials like household ceramics, coathangers. Soft plastics (shopping bags, saran wrap, ziplock and chip bags etc) are not recyclable in the UBC system, but many residents consider it plastics and think it can go in with rigid container materials. Some bag all their cans and bottles in one plastic bag and throw it into the recycling bin.

Paper Stream

Paper weight showed no significant changes under any intervention. This effect is possibly due to several key factors: i) paper is lightweight compared to other household waste materials so changes in weight are less significant; ii) Logan Lane (one of the biggest buildings in the study) collects paper with cardboard in a large metal receptacle which we could not measure due to its size and weight; and iii) it is possible that paper diversion is close to best achievable. Regarding contamination of paper bins, we found that both type of signage and door to door intervention helped reduce contamination compared to baseline, but without statistical significance ($p=.10$). There was no difference between buildings that did door to door and those that did not. The contamination of paper in post-intervention went slightly up, but remained below baseline levels. The most common paper contaminants were mixed material items that have plastic on the inside

but paper on the outside (such as coffee cups and ice cream containers), and soft paper items like paper tissues (hand paper towels or Kleenex) which belong in the compost bin and not with sheet paper. Instances like these show us that many people lack specific knowledge about contamination, and often follow intuitive assumptions when sorting waste.

This study had several limitations:

i) Since there was no control in the study (all buildings participated in interventions), we cannot say that changes observed were not due to chance. Future studies should ensure there is at least one building in the control condition to better compare the effects of interventions on each individual building or as a group.

ii) In interest of time, this study used a staggered interventions approach which might have created cumulative effects of some interventions, such as door to door canvass which was the last intervention after six months of working with the communities. We also had uneven breaks between interventions. Future research should ensure all interventions have the same incubation period, and allow for a 2 to 3 weeks of post-intervention period between each intervention before proceeding with the next intervention.

iii) Another major limitation of this research was the inability to thoroughly inspect waste bins. When bins are full or overflowing (especially compost/ organics) it is very difficult to rummage through and see all the contents and count for contamination. As such we must take contamination data with caution as a possible trend, and not a definite representation. Future work should attempt a more rigorous contamination inspection for all bins to be able to see and count all contamination per bin per waste stream, to better validate intervention effects.

RECOMMENDATIONS

1. UNA Strata and Building Managers

i) Infrastructure

- Recycling room infrastructure should be made as convenient and pleasant as possible with all recycling and compost bins together inside the recycling rooms (not held separate) to streamline the sorting process. Similar bins should be placed side by side and not split up in-between streams: Place paper bins next to cardboard bins, compost close to garbage to throw away any plastic bags, and glass or return it containers next to plastics recyclable containers).

- Bin lids should ideally not be closed since people have trouble opening and closing all the lids while trying to sort waste. Lids should also not be leaning against the wall, especially if there is signage they would block. Lids should be flipped over and bins pushed against the wall to not hide signage and prevent overstocking of material, as people sometimes pile materials in one bin that is open even if adjacent bin is empty but has a closed lid.

- In-suite infrastructure can be a barrier to participation if residents don't have a way to gather recycling and composting materials inside their units. If possible provide residents with free or discounted recycling and composting materials to entice participation: small recycling and compost bins, bin-liners, etc.

- Incorporate zero waste norms and practices within the building events to send social cues that this is a desired behaviour others are doing (i.e. make every event a zero-waste event, organize clothing/ household donation drives, discuss recycling participation in strata meetings).

ii) Communication

- Ensure all recycling rooms have relevant signage clearly visible above bins, obtained from waste hauler websites, UNA or UBC sustainability office[12]. Do periodic checks for system changes, or damage to posters.

- Ensure all existing and incoming tenants get verbal and written information about the recycling and composting program. This includes why it is important (bylaw policy, resource efficiency and being a part of Vancouver culture), and given info on what goes where. Inform new residents that the building norms are to recycle and compost can be very effective upon move in, as people may be more likely to fit in and change habits.

- Communicate with waste haulers if bins are broken, insufficient, dirty or sticky to be taken out and replaced.

[12] For waste collected by UBC: UBC Sorting Guide and resources: https://sustain.ubc.ca/campus-initiatives/recycling-waste/sort-it-out/resources

- Conduct contamination checks which materials are most commonly mis-sorted and communicate with residents through internal channels: letters, meetings, elevator or message boards. Focus on one or a few items (i.e. no plastic bags in compost bins, No Styrofoam and soft plastics in recyclable containers) instead of trying to communicate all the issues at once.

- Stay positive and constructive: sometimes residents get discouraged and think fellow residents don't care. Showcase improvements and collective contributions (everyone is doing it!) which is proven to help participation.

2. Recommendations for UNA, UBC and Metro Vancouver

i. We found that "Food is not Garbage" posters were very effective at increasing participation in the organics program, but did so at the expense of contamination. Therefore, we recommend that such interventions be paired with (or followed by) interventions that help inform and educate residents on what material to keep out.

ii. Continue working closely with MURBs through Zero Waste Committees to share best practice, support and resources.

iii. Provide recycling alternatives for common household items that can't be recycled in the regular waste streams, such as kitchenware, batteries, e-waste and soft plastics. Advertise reuse programs within a given community (i.e. UBC Free Store, Facebook pages) where residents can drop off items, or partner with organizations that can come pick up items.

3. Recommendations for further MURB research

i. Future studies of MURBs on campus should ensure there is one (or several) buildings in the control condition to better assess and compare effects of interventions. Additionally, compare effects on each individual building in the study.

ii. Similarly, future research should ensure all interventions have the same incubation period, and allow 2 to 3-week post-intervention period before proceeding with the next intervention.

iii. Future work should implement a more rigorous contamination inspection for all bins (especially compost) to be able to better validate intervention effects. Inclusion of the garbage bins would further help discern true diversion effects.

iv. Further research is needed on strategies to cut down specific contamination, such as plastic bags and Styrofoam in compost and recyclable containers.

APPENDIX

APPENDIX A - SORTING GAME PILOT POSTER

Let's improve recycling and composting in this building.

Play this fun game to learn about sorting and win a prize!

http://yuluo.psych.ubc.ca/studies/Sorting_MD/

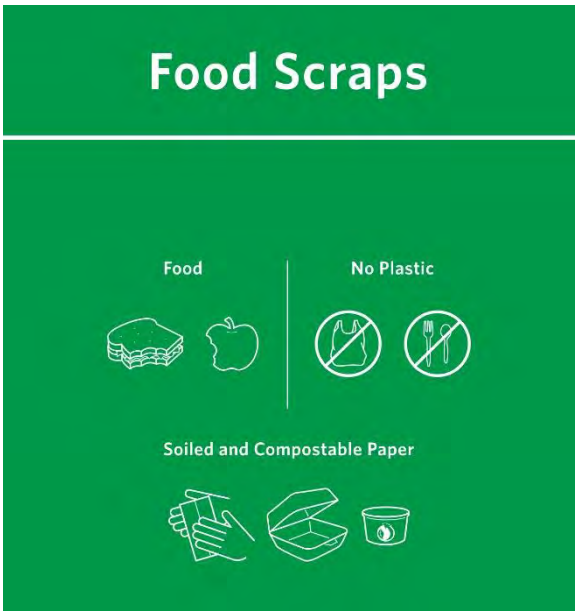
The person with the highest score wins a $50 save on foods card!

UBC is aspiring to be a "Zero Waste" campus where all waste will be recycled. UBC is matching Metro Vancouver's target to divert 80% of recyclable materials from landfills by 2020.

Please help us reach this goal!

APPENDIX B – REGULAR SIGNAGE POSTERS

Example of basic signage obtained from UBC Campus Sustainability, used in buildings that are serviced by UBC.



APPENDIX C – NEW VISUAL SIGNAGE POSTERS

REFERENCES

1. World Bank, (2010). Part III: Cities' Contribution to Climate Change, in Cities and Climate Change: An Urgent Agenda. Volume 10. Washington DC: The International Bank of Reconstruction and Development. The World Bank.

2. UBC (2016). Annual Sustainability Report, 2015-2016. Available at http://report.sustain.ubc.ca/wp-content/uploads/2016/12/2015-2016-Fast-Facts.pdf

3. City of Vancouver, (2017). Greenest City Action Plan, Goals and Targets: Zero Waste. Available at: http://vancouver.ca/green-vancouver/zero-waste.aspx

4. UBC Zero Waste Action Plan, (2013). Campus and Community Planning, Campus Sustainability. Available at: http://report.sustain.ubc.ca/wp-content/uploads/2016/12/2015-2016-Fast-Facts.pdf

5. UBC Communications and Marketing, (2014). Recycling and Composting Attitudes and Behaviours. (2014) Final Report prepared by John Lo.

6. Kahneman, D. (2011). Thinking, Fast and Slow. Farrar, Straus and Giroux.

7. Mckenzie-Mohr, D. (2008). Fostering Sustainable Behaviour: Beyond Brochures. International Journal of Sustainability Communication, 3, 108–118.

8. Wu, D. W. L., DiGiacomo, A., & Kingstone, A. (2013). A Sustainable Building Promotes Pro-Environmental Behavior: An Observational Study on Food Disposal. PLoS ONE, 8(1), 1–4

9. DiGiacomo, A., Wu, D. W.-L., Lenkic, P., Fraser, B., Zhao, J., & Kingstone, A. (2017). Convenience improves composting and recycling rates in high-density residential buildings. Journal of Environmental Planning and Management, 1–23

10. Downloadable posters and social media images from Metro Vancouver: http://www.metrovancouver.org/services/solid-waste/recycling-signage-campaigns/campaign-posters-artwork/Pages/default.aspx

11. Zhao Lab Sorting Game with Feedback. Available online, designed by Yu Luo: http://yuluo.psych.ubc.ca/studies/Sorting_MD/

12. UBC Sorting Guide and Resources: https://sustain.ubc.ca/campus-initiatives/recycling-waste/sort-it-out/resources