

Understanding Illegal Dumping in Baltimore City and Identifying Targeted Interventions

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Abstract

Overall, illegal dumping 311 Reporting and related Environmental Citations are increasing. For 311 Reporting, API and Phone were the most common reporting styles, however the reporting style does not affect the total number of citations per district. Through a cluster analysis that identified specific neighborhood ‘hotspots’ with the highest reports and citations in Baltimore, the suggested targeted interventions include improving communication and transparency with reporters, modifying the current surveillance system, and implementing a cash reward program. Additional research includes comparing trash drop off centers to the hotspots, analyzing the effects of population change, and comparing the hot spots results to demolition/construction data.

Problem Statement Background + Additional Resources and Examples

Illegal trash dumping is a growing and pervasive problem in Baltimore City. Annually, around 10,000 tons of trash are illegally dumped in this city as of 2018, according to the Department of Public Works (Baltimore Sun 2019). The Department of Housing and Community Development issued almost 1,150 citations for illegal dumping in 2018, with fines ranging from \$50 - \$30,000 (Baltimore Sun 2019). By understanding the trends and exploring possible interventions to prevent illegal dumping, we will understand the next step city government should take to reduce illegal dumping.

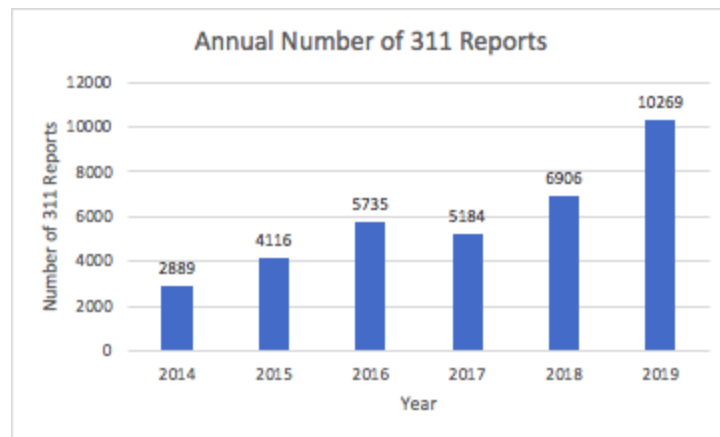
Other major cities have also faced illegal dumping challenges. For example, LA is trying to increase surveillance and clean up programs to reduce dumping in streets, as it is a safety and health hazard for everyone (Quintana 2019). Cleaning up trash is also quite costly for the city. Major cities including Cleveland, Omaha, St. Louis and Philadelphia have implemented incentive programs and increased surveillance systems to combat this issue (Quintana 2019).

By analyzing Baltimore City 311 reporting data and Environmental Citations data, there has been an uptick in both reporting and environmental citations since 2014 and 2004, respectively. 311 reports and environmental citations are increasing exponentially, and are expected to increase in future years. As a result, these trends confirm that illegal dumping is increasing and immediate solutions are required to address the problem.

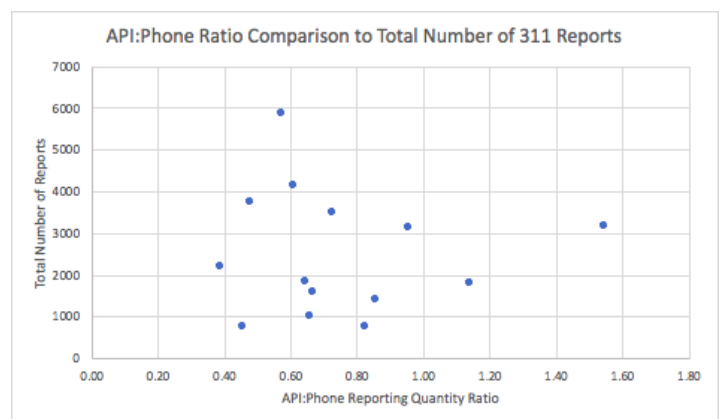
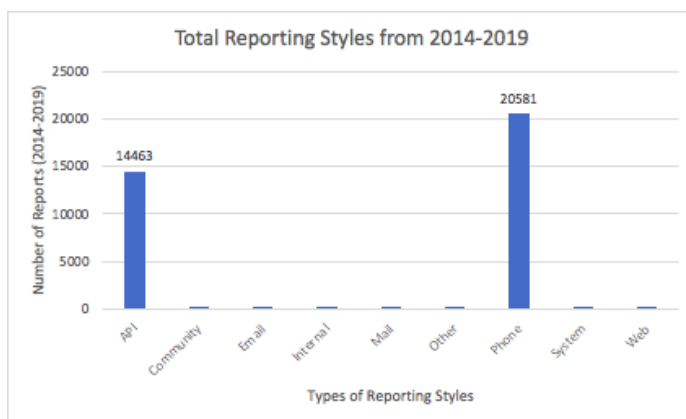
Data Findings and Interpretations

Our approach is two fold: first, we wanted to find trends from the 311 Reporting and the Environmental Citations datasets, and identify the relationships between the two datasets. Second, we identified ‘hotspots’ with high illegal citations and reports, which give insight into specific areas to target on a city council district level and neighborhood level.

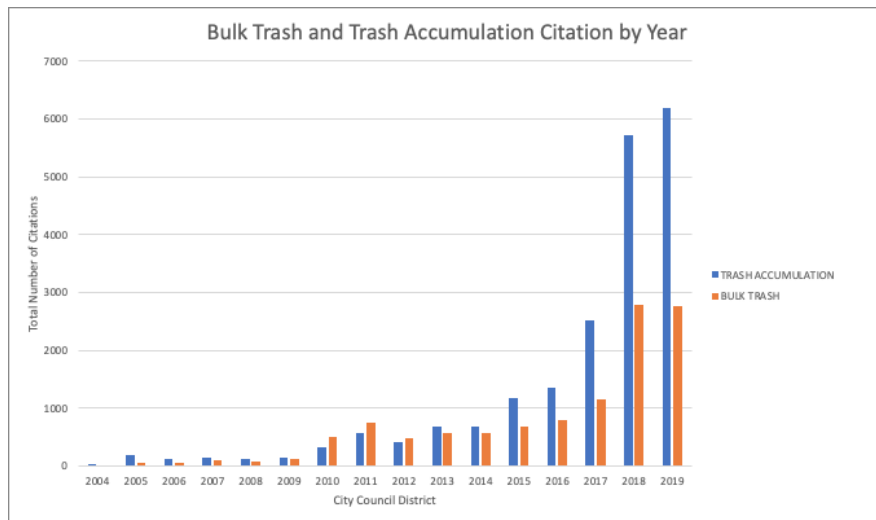
311 Reporting: The number of 311 reports increase annually from 2014 (2,889 citations) to 2019 (10,269 citations). Geographically, District 9 had the highest number of illegal dumping citations (5,877) across all years. To dive deeper, we wanted to better understand if Baltimore has more efficient reporting methods that led to increased reporting, or if Baltimore was becoming dirtier? Of all reporting styles (API, email, mail, phone, system, and web), API and Phone had the highest number of reportings, with Phone being consistently higher than API.



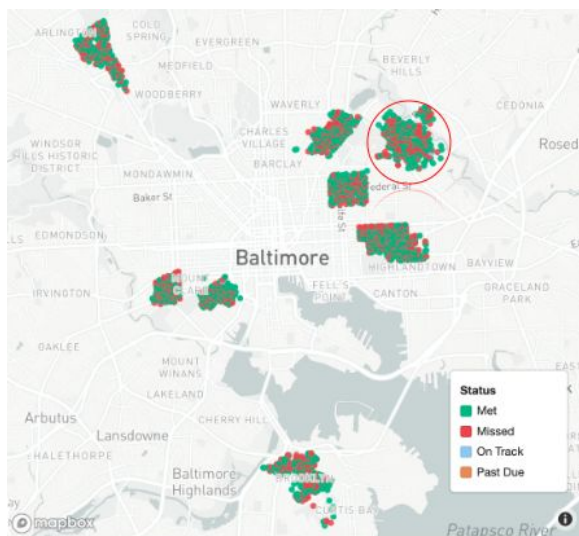
We wanted to see if the type of reporting affected the total number of reports on a district level. By identifying the District API:PHONE ratio compared to the number of reports, although there is higher phone use, the reporting style does not lead to more or less reports. Lower API:PHONE ratios resulted in both high and low reports in multiple districts. Therefore, the method of reporting doesn't affect reporting quantities, but overall there is still an increase in reporting over the years (data analysis process in Appendix).



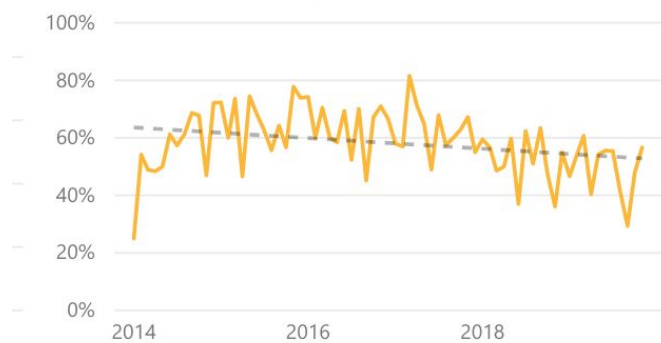
Environmental Citations Findings. The data collected for illegal dumping citations was inaccurate and corrupted. As a compromise, we focused on citations similar to illegal dumping, including Trash Accumulation and Bulk Trash citations. From 2004-2019, there is an exponential increase for both citations, again confirming the magnitude of the trash problem.



Second, we conducted a cluster analysis to identify neighborhood clusters with high 311 illegal dumping reporting, and high environmental citations in Bulk Trash and Trash Accumulation. Through the analysis, five clusters were identified: Abell (1), Canton (2), Better Waverly (3) Belair Edison (4), and Broadway East (5). By utilizing the 311 dashboard, we mapped out the clusters with the top number of reporting and citations, which were Clusters 4 and Cluster 5. Cluster 4 was entirely Belair Edison (inside the red circle), Cluster 5 was made up of 13 neighborhoods (outside red circle, including Baltimore Highlands, Broadway East, Brooklyn, Carrollton Ridge, Central Park Heights, Coldstream Homestead Montebello, Ellwood Park/Monument, McElderry Park, Patterson Park, Washington Village/Pigtown). Overall, there is a high concentration of high illegal dumping/trash occurrences in the NW region of Baltimore. If the Percent of Service Requests Closed Overtime in Clusters 4 and 5 continues decreasing, residents may be hesitant to report if their requests aren't addressed as quickly.



Percent of Service Requests Closed on Time



Concrete Recommendations and Impact for Baltimore City

311 Reporting Communication Initiative

- *Significance*: This is a simple, short term solution to increase reporter trust, communication, and engagement. 311 reports have increased, they are expected to continue increasing, and it is essential to encourage reporting or maintain the observed level of reporting. Reporters are hesitant to report because they don't trust the government to properly address the situation. Because Baltimore residents are the eyes and ears of the city, reporting plays an integral role in informing city government about illegal dumping occurrences. It is essential to build and strengthen reporter engagement.
- *Supporting Data*: The data shows API and Phone are the most popular reporting styles; this also shows that most reporting comes from residents rather than city government. As a result, it is essential to continue engaging reporters by increasing communication through these platforms will further encourage citizens to make 311 reports. The data also shows that there is a decreasing number of Percent of Service Requests Closed on Time, and if the city is more transparent about the process and is required to keep reporters updated, this will increase their accountability to follow through with these requests.
- *Action Item*: City government should increase the level of feedback and transparency that citizens receive after making a report will be beneficial. After someone makes a report through the phone or API, a message either via text or email should be sent. This message should thank the individual for reporting, outline the following steps (including the amount of time to process and address the report), and provide a link to its status update. Lastly, individuals should be notified when the report has been resolved.
- *Implementation*: The timeline for this is very immediate, as increasing both the content of the messages and frequency of the messaging can be added in the next couple weeks. Since city government already has the reporters' contact information, this is a simple administrative change to increase communication with reporters through email or text message. If successful, reporters will continue to check in on their report status, and there may even be an increase in reporting as reporters begin to trust city government.

Modification of the Current DHCD Surveillance Program:

- *Significance*: This is a long term solution to improve the current surveillance program by prioritizing the hotspots identified through the cluster analysis. The technology itself is effective, however there is still an increase in citations. By targeting these high risk illegal dumping neighborhoods, there should be a decrease in overall illegal dumping.
- *Supporting Data*: DHCD has a system where 90 surveillance cameras are rotated between over 100 hotspot illegal dumping locations throughout each week to identify perpetrators (DPW Annual Report 2018). We do not have access to DHCD's hotspots, but through the cluster analysis, we've identified hotspot illegal dumping neighborhoods with high reporting and citations.

- Action item: The neighborhoods we found should be included on the DHCD list of hotspot locations and prioritized, if they have not been already. In addition, we recommend more time spent at these locations in the rotation or additional cameras in place there. The camera rotation schedule is also unknown, but DHCD should randomize rotation order, so perpetrators cannot figure out optimal times to dump at these sites. If perpetrators know the routine, they will likely dump in other locations to avoid cameras.
- Implementation: City government must work with groups maintaining these cameras to understand the rotation schedule and locations to re-strategize based on these recommendations. After their approval, this can be implemented in the next couple weeks/first month. Additional personnel may be required to ensure correct placement of these cameras. There is no additional cost, as Baltimore already has this camera system.

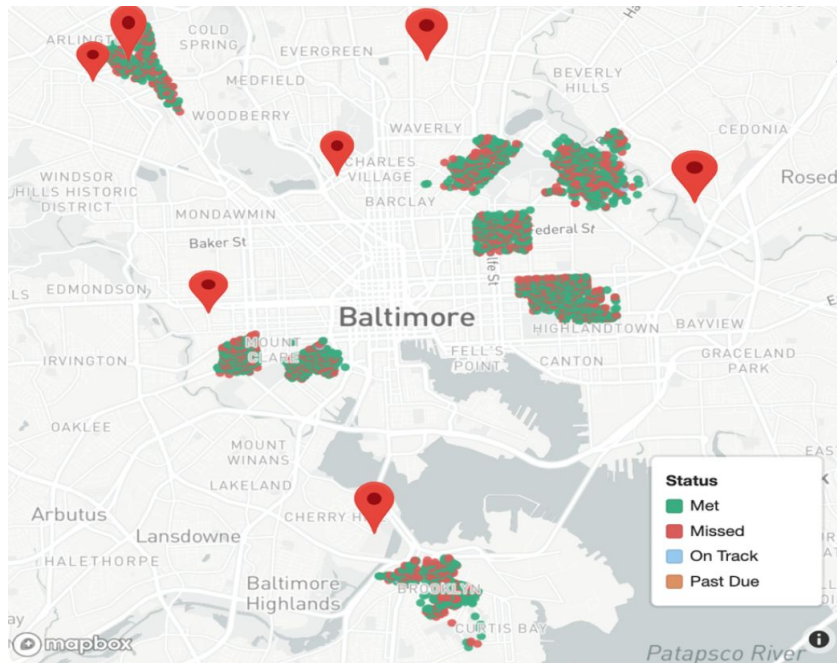
Cash Reward/Incentive Program:

- Significance: This is a long term solution that continues to increase reporter engagement, thus increasing the total number of reports to assist city government.
- Supporting Data: As mentioned before, both 311 reports and environmental citation reports have been going up. Reporting is important for the city to understand illegal dumping occurrences. This program has been implemented previously in Baltimore in 2002, and we propose to reinstate this program. Other cities have also implemented a reward system, such as Dallas, Oakland and Chicago, to combat illegal dumping of large, arrestable amounts.
- Action Item: The DHCD should collaborate with the BPD to distribute rewards to illegal dumping reports/tips that lead to arrests. Based on the rewards given in other cities, and the severity of large scale dumping in Baltimore, we would recommend setting the reward amount at \$100.
- Implementation: Based on the budgets allocated in other city's programs we predict that this program will cost roughly \$50,000 initially, but will ultimately save the city money by reducing the costs of cleaning up trash every year.

Additional Research

Drop Off Center vs. Hot Spot Location

By comparing the trash Drop Off center locations (marked in red below) to the hotspots we found that all of the hotspot neighborhoods we had identified are within 3 miles of the city's 8 legal dumping sites, the average distance between the sites and these neighborhoods being 1.7 miles. Central Park Heights (NW region) has 2 drop off centers within the neighborhood itself. This highly suggests that there may be trash overflow around these drop off centers, leading to high numbers of 311 reports and environmental citations.



Population (Refer to Appendix)

Within the hot spot neighborhoods, as population increases, reporting density decreases. However, all neighborhoods are consistently reporting an average of 500-700 reports over the past 5 years, so population number does not affect total reports, but increasing population can affect total reporting density.

Housing Market Typology

By comparing the housing market typology map and our cluster analysis map, high illegal dumping neighborhoods correlated with low housing market costs, ranging from \$15,000-75,000. Either the presence of trash is reducing market value, or the illegal dumping is targeting places with lower market value.

Future Research

Future research includes comparing illegal dumping reports to construction or demolition areas to identify if these areas also experience high numbers of illegal dumping reports. In addition, because of the environmental citations data error, we encourage the data management team to consistently update and provide accurate data on the open city website. If Baltimore's mission is to engage residents to utilize this data source, the data should accurately reflect the trends in Baltimore. Lastly, city government can identify trends in 311 reporting vs. seasonality through additional cluster analysis.

Appendix

Additional Sources:

- Baltimore City Department of Public Works Annual Report
 - <https://publicworks.baltimorecity.gov/sites/default/files/Annual%20Report%202018.pdf>
- Oakland Public Works Illegal Dumping Reward Program press release
 - <https://www.oaklandcityattorney.org/PDFS/Press%20Releases/Oakland%20Public%20Works%20Reward%20for%20Reporting%20Illegal%20Dumpers%20Press%20Release.pdf>
- Baltimore Sun Illegal Dumping Statistics
 - <https://www.baltimoresun.com/maryland/baltimore-city/bs-md-ci-illegal-dumping-20190620-story.html>
- Baltimore City Department of Public Works Citizen Drop-Off Centers
 - <https://publicworks.baltimorecity.gov/solid-waste/drop-off>
- City governments experiencing illegal dumping
 - <https://www.govloop.com/community/blog/cities-are-cracking-down-on-the-illegal-dumping-crisis/>

Excel Procedures

To clean both datasets first filter them by the types of the citations/reports to get the specific, desired categories. For the 311 data we did this prior to downloading the data, on the OpenBaltimore website. Select the Filter option to the side, set the filter column to “SRType” and the filter operation to “HCD - Illegal Dumping”. Click on Export and select “csv for excel”. In both datasets we highlighted all the columns that were not relevant to our analysis (DueDate, Agency, Violation Code, Lien Code, Fine Amount, Balance, LastPaidAmount, LastPaidDate, LastPaidDate, Total Paid, CitationStatus, HearingRequestreceivedData, HearingDate, Hearing Status, Block, Location) and deleted them.

To create the cluster analysis, first isolate the needed data from the pivot tables. Copy the list of neighborhoods and pasted them in the cluster analysis along with their corresponding report and citation numbers. Above each column we calculated their corresponding mean value (using the AVERAGE function) and standard deviation value (using the STDEV function). To the right of these values create three columns to calculate the z-scores of values. Create a simple arithmetic function where each value’s mean is subtracted from the value, then this is divided by the standard deviation. Above these values create an anchor table. The table should have 5 columns (Name, Anchor, Trash Accumulation, Bulk Trash and Illegal Dumping). In the Anchor column pick 5 numbers at random that have a corresponding neighborhood in the dataset. In the Name column create a VLOOKUP function to match the Anchor numbers to their corresponding Name

To the right of this, create 5 columns (one for each anchor) to calculate the distance squared to the particular anchor. Do this using the SUMXMY2 function with the first criteria selecting the corresponding range of data in the anchor table and the second criteria, selecting the corresponding z-score values. Do this across the 5 columns. Create a min squared distance column, use the MIN function to find the lowest value in the distance squared row. Then create a segment column using the MATCH function and selecting the min squared distance value for the first criteria and then, the distance squared values for the second criteria. Finally, run the analysis. Make sure the Solver add-in is loaded. Go to the Data tab. Select solver. Make the Set Objective the Sum squared distance cell. Set the “Changing Variable Cells” to the column of selected anchor numbers. In the “Subject to the Constraints” section, you should have three items all using the selection of the anchors (in this case K3:K7). Include one item where the selection is less than or equal to your total number of potential anchors (neighborhoods), one item where the selection is equal to integer and one where the selection is greater than or equal to 1. Uncheck “Make Unconstrained Variables Non-Negative”. Select “Evolutionary” as the Solving Method. Then click solve and let the analysis run.

311 Analysis

The first step was to clean the data: the data used only included SRTYPE (illegal dumping), method received, Created Date, Neighborhood, and Council District. To analyze annual trends, a pivot table was used with the Create Date and the Count of SRTYPE to identify annual numbers of 311 reports.

Pivot tables were used to understand annual, monthly, district and neighborhood trends. To understand reporting styles, we took the ratio of total API reports and Phone reports (x axis) compared to the total number of reports (district level) to find any trends. Then, we used a pivot table to create a scatter plot to show the relationship.

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