Statistical Evaluation of Industrial Stormwater Discharges from Fertilizer Mixing Facilities

Behrooz Pakzadeh

ABSTRACT

This study will give background data regarding the types of pollutants and the concentrations of those pollutants that we may anticipate originating from a particular kind of industry. The seasonal variation of Best Management Practices (BMPs) is explained primarily by runoff volume dependency of heavy metals. Results of this study will provide some of the background data of types and relative concentrations of contaminants needed in issuing permits for stormwater discharges from individual industrial sites. This data may also serve as a comparison to sampling results submitted by industries as part of their stormwater permit requirements.

In addition to causing significant harm to surface water quality, stormwater runoff from industrial facilities may also significantly complicate the compliance process. Among them are the discharges from the fertilizer mixing plants. This study was done in order to gain a deeper understanding of the component discharges from these sorts of facilities and to assess the storm water seasonal fluctuation. A statistical analysis was used to evaluate self-monitoring and self-reporting data. The conclusion will serve as a foundation for future research and, in the long term, as a policy suggestion.

In accordance with statistical analysis, heavy metals and NPK Compound Fertilizers are mostly related with certain kinds of industry.

The SWPPP and statistical analysis demonstrated that non-industrial sources also contribute to the concentration of investigated parameters in stormwater discharges, particularly zinc, iron, and total suspended particles. PCA investigated the seasonal differences in stormwater quality. It was determined that the second half of the stormwater season was inferior to the first.

The seasonal variation of the BMPs is explained primarily by runoff volume dependency of the heavy metals.

INTRODUCTION

According to the definition provided by the United States Environmental Protection Agency (EPA), storm water is the runoff that is produced when precipitation from rain and snowmelt events travels over land or impermeable surfaces without percolating into the ground (US EPA, 2020).

Pollutants like used motor oil and trash can be transported by storm water from different sources such as municipal separate storm sewer systems (MS4s), construction activities, and industrial activities into the Water of United States (WOUS) (Storm Water Program | California State Water Resources Control Board, 2022).

Under the Clean Water Act (CWA), it is illegal for any entity to discharge pollutants through a point source into the WOUS unless they have a valid National Pollutant Discharge Elimination System (NPDES) permit (US EPA, 2015).

The Nationwide Urban Runoff Program (NURP) identifies industrial land uses among the sources of pollutants in urban stormwater runoff (Bernstein 2009). The Industrial General Permit (IGP) is an NPDES General Permit in California and regulates industrial storm water discharges and authorized non-storm water discharges from industrial facilities in California. Despite the fact that California has significant stormwater compliance standards and regulations, there is little literature on industrial storm water discharges and authorized non-storm water discharges from industrial facilities. Additional research into industrial storm water discharge will shed light on the accuracy of the data collected by the self-monitoring systems.

In addition to the technique for self-monitoring that has already been created, there is a pressing need to develop other approaches for evaluating industrial operations in terms of the extent to which they contribute to the concentration of pollutants in stormwater (Cross 2008). Therefore, the implementation of a project can be beneficial in regard to this issue.

OBJECTIVE

The EPA estimates the potential hazard of pollutant discharges in terms of toxic-weighted pound equivalents (TWPE). Industrial facilities recognized with the SIC Code of 2785 – "Fertilizers, Mixing Only" rank high in terms of toxic-weighted pound equivalent (TWPE), in point source category rankings. Because of this, the first objective of the final project is to conduct statistical analyses to identify the impact of seasonal changes on the concentration of pollutants in the stormwater runoff samples collected in ten industrial facilities categorized under SIC Code of 2785. The second objective is to determine whether or not there is a correlation between the constituent concentrations observed in the stormwater samples and in the target industrial facilities.

DATA SOURCES

In the majority of cases, industrial facilities in California may be required to file a Notice of Intent (NOI) through the Storm Water Multiple Applications and Report Tracking System (SMARTS) with the State Water Resources Control Board (Water Board) to obtain coverage under the IGP. An industrial facility with an active NOI coverage is required to meet all the applicable requirements in the IGP (Storm Water Program | California State Water Resources Control Board, 2022). The following is a summary of the main requirements for the active NOI coverage holders: 1. Conducts Monthly Dry Visual Observations 2. Collect and Analyze Stormwater Samples 3. Perform Visual Observations of the Stormwater Samples 4. Conduct an Annual Comprehensive Facility Compliance Evaluation (Annual Evaluation).

Collected storm water samples were analyzed for total iron (Fe), total lead (Pb), total zinc, total phosphorous, total nitrate nitrite as nitrogen (N+N), total suspended solids (TSS), total oil and grease, and pH.

The laboratory analytical storm water results of ten industrial facilities with the SIC Code of 2785 – "Fertilizers, Mixing Only" located within the Central Valley Regional Water Quality Control Board (5S) were obtained from the Storm Water Multiple Application and Report Tracking System (SMARTS). SMARTS is designed by the State Water Board to enable permittees to electronically submit permit compliance data. The system makes reports and information on stormwater quality management initiatives available to the public (Storm Water Program | California State Water Resources Control Board, 2022). The data was screened to include the storm water analytical data from the 2018-2019, 2019-2020, and 2020-2021 storm water reporting year. There was a gap in the SMARTS' collection of analytical data pertaining to stormwater. The facilities' Annual Evaluation revealed that the justification was determined to be either a lack of rain or inadequate discharge to capture samples; hence, part of the stormwater analytical data could not be recovered.

Table 1. below shows the details about the selected facilities.

Table 1

Facility Name	Type of Permit	Statues	Area Directly Exposed Rainwater
5S1	Industrial	Active	0.5 acres
5S2	Industrial	Active	12 acres
5S3	Industrial	Active	1 acre
5S4	Industrial	Active	2.5 acres
5S5	Industrial	Active	0.1 acres
5S6	Industrial	Active	0.32 acres
5S7	Industrial	Active	0.4 acres
5S8	Industrial	Active	15 acres
5S9	Industrial	Active	32 acres
5S10	Industrial	Active	1.6 acres

In order to determine whether or not the analytic data follow a normal distribution, the Excel add-in provided by Unistate Statistic Software was used. The theoretical distribution that gave the best results in terms of fitting the data was chosen with the use of the 2-test and the Kolmogorov-Smirnov test

(Antonopoulos 2001). Since more than three parameters are needed for comparison and each parameter belongs to a different facility, the non-parametric Kruskal Wallis test was used (Graham Hole Research Skills Kruskal-Wallis handout 2022). The principal component analysis (PCA) was used to determine the correlation between potential pollutant sources listed in the facilities' SWPPPs and analytes. Additionally, seasonal correlations of stormwater quality parameters were determined by PCA (Salehi 2020). Two storm water samples must be collected in the first half of the storm water year (July to December) and two more samples in the second half of the storm water year (January to June). So, the data was divided into two temporal databases.

In principal component analysis, the number of variables that serve as input is equal to the number of extracted components. There were eight different parameters that were analyzed in the samples of storm water, and thus, there were eight different component parameters that were extracted. However, only the components that had a substantial total variance were considered to be the most significant (Salehi 2020).

RESULTS

All the parameters, including heavy metals (Fe, Zn, Pb), macro-nutrients (N+N, P), and basic parameters (TSS, O&G, pH), were detected in the stormwater sample collected within ten targeted sites. However, Pb and O&G were not detected in the samples collected during two QSE in the first half of the year at 5S1, 5S7, and 5S8. Table 2 below shows the percentage of the annual average concentration of the parameters that were above the annual average of Numeric Action Levels (NAL) for the associated pollutants. The median concentration of the parameters is compared in the figures 1 to 8. All the facilities, with the exception of one, have overall lead concentrations, as well as oil and grease levels, that are below the annual NAL. An analysis of the significant materials listed in the SWPPPs revealed that the facilities that had more motor oil storage had higher concentrations of total zinc than the other facilities.

According to the assessment of available literature, the motor oil does contain zinc (Brown 2006). High concentrations of zinc could originate from motor oil and hydraulic fluid and tire dust (Peng et al., 2017). The measured pH within all facility was between 6 to 9 which is between the defined range in the IGP. Oil and grease, iron, and total suspended solids medians showed a wide range of variants between the facilities (Table 3 and Figures 1-8). In the facilities SWPPP, a large amount of the roof and other impervious surfaces were mentioned. Roofs are mostly made of zinc and copper (Wallinder 2000). As a result, roof runoff in the buildings might be a non-industrial source of metals (mainly zinc).

Table 2

PARAMETERS	**FACILITATES**									
	5S1	5S2	5S3	5S4	5S5	5S6	5S7	5S8	5S9	5S10
IRON, TOTAL	63	25	69	78	31	21	80	93	21	34
ZINC, TOTAL	54	32	21	42	45	35	45	34	28	39
LEAD, TOTAL	ND	ND	ND	2	21	ND	ND	ND	0.4	0.2
NITRITE PLUS NITRATE (AS N)	23	45	51	67	91	21	11	ND	21	32
OIL AND GREASE	ND	ND	2	4	31	0.5	ND	ND	0.3	0.1
PH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHOSPHORUS, TOTAL (AS P)	24	46	59	63	70	31	11	ND	24	31

TOTAL SUSPENDED SOLIDS	65	35	70	73	30	25	78	90	20	30

Table 3

	Iron, Total	Zinc, Total	Lead, Total	Nitrite Plus Nitrate (as N)	Oil and Grease	pH	Phosphorus, Total (as P)	Total Suspended Solids
	5.1	0.12	0.0022	9.9	0	7.8	1.5	62
	10	0.29	0.0029	26	1.8	8.2	1.5	150
	3.2	0.53	0.005	4.5	0	7.7	1.9	55
	3.2	0.53	0.0022	4.5	0	7.7	1.9	55
	7.4	0.43	0.0033	5.2	1.5	7.6	0.59	110
	1.1	0.082	0.00046	12	1.5	7.7	2.2	11
	6.6	0.28	0.0032	75	1.6	7.73	4.1	110
	27	0.81	0.012	14	1.5	7.7	1.8	110
Median	5.85	0.36	0.00305	10.95	1.5	7.7	1.85	86
STD	8.188843	0.241062	0.003511	23.76266	0.130384048	0.183532	0.997539	44.51143513
95 Percentile	21.05	0.712	0.00955	57.85	1.76	8.06	3.435	136

Table 4

	Iron, Total	Zinc, Total	Lead, Total	Nitrite Plus Nitrate (as N)	Oil and Grease	pH	Phosphorus, Total (as P)	Total Suspended Solids (TSS)
	5.1	0.12	0.0022	9.9		7.8	1.5	62
	10	0.29	0.0029	26	1.8	8.2	1.5	150
	3.2	0.53	0.005	4.5		7.7	1.9	55
	3.2	0.53	0.0022	4.5		7.7	1.9	55
	7.4	0.43	0.0033	5.2	1.5	7.6	0.59	110
	1.1	0.082	0.00046	12	1.5	7.7	2.2	11
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Figure 1

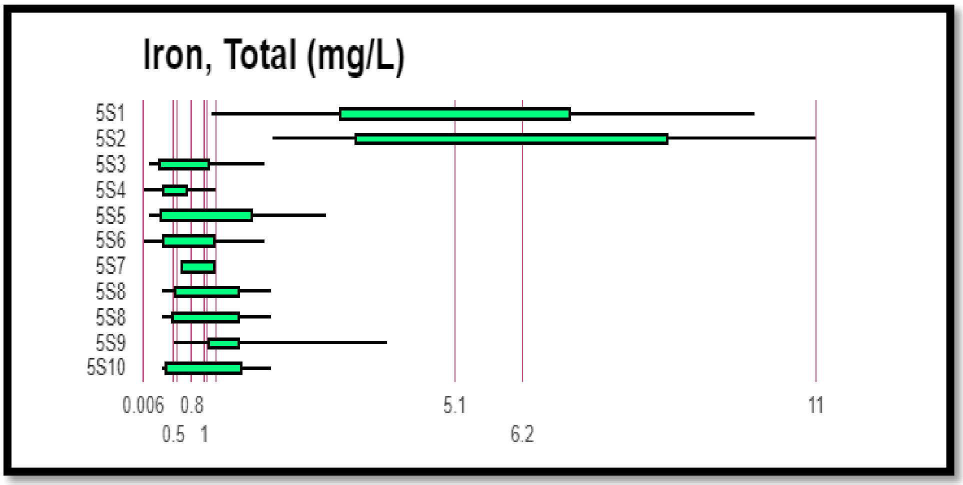


Figure 2

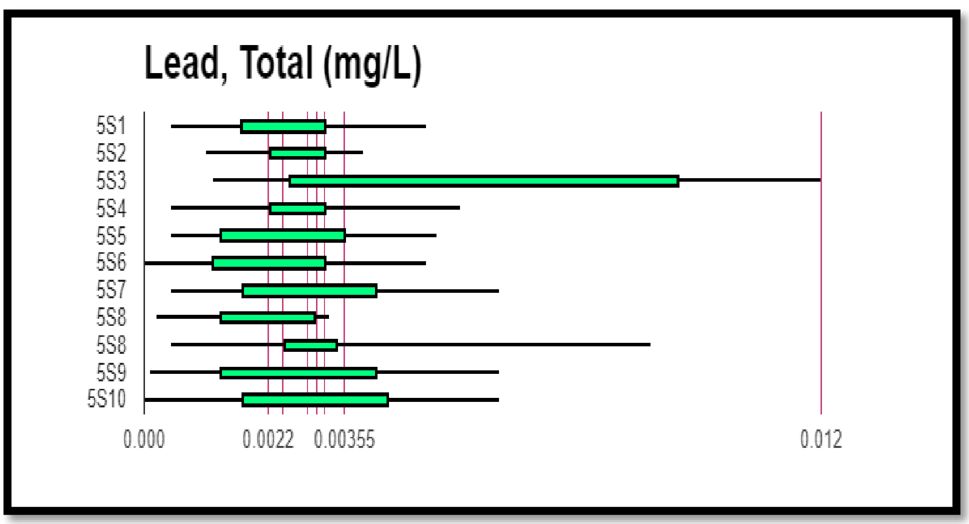
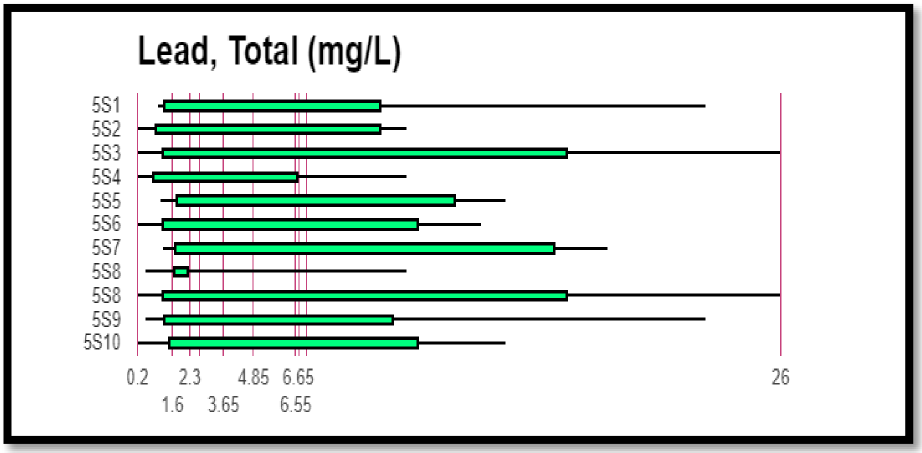


Figure 3



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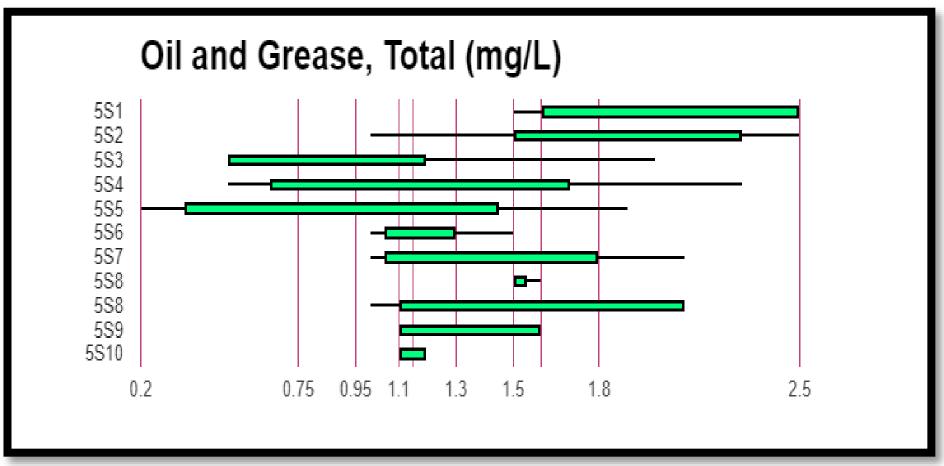

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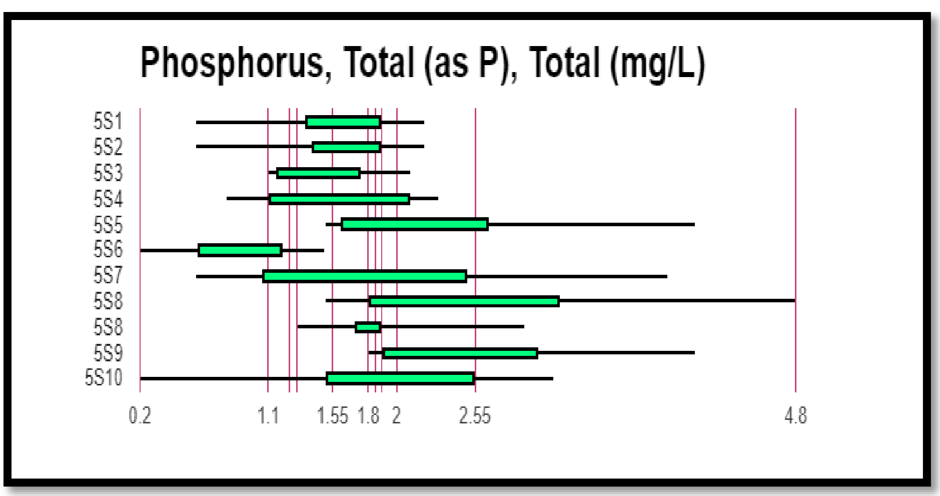

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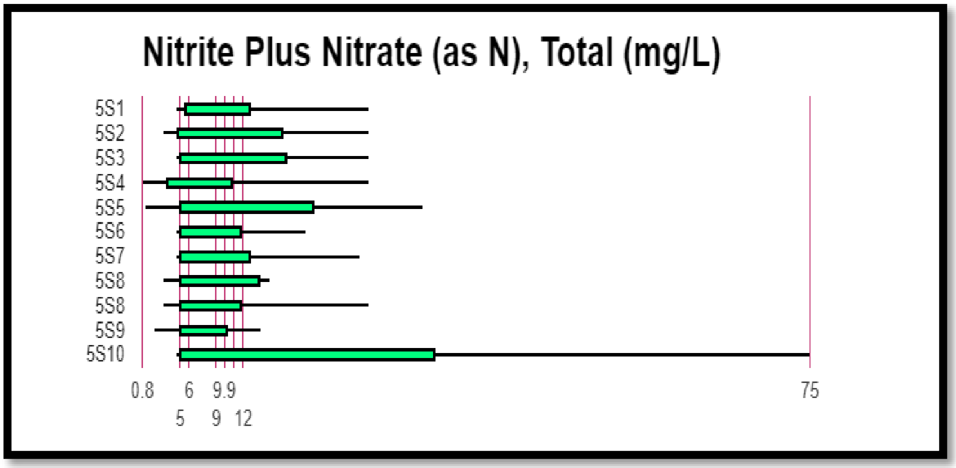


Figure 7

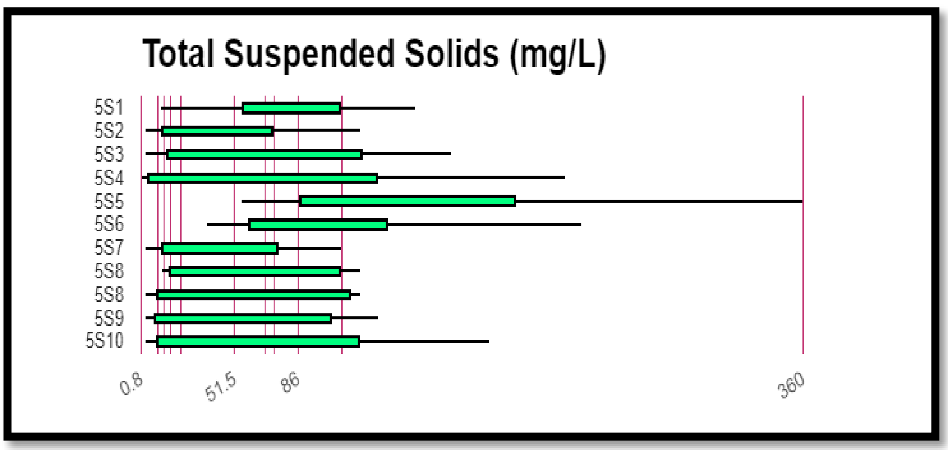
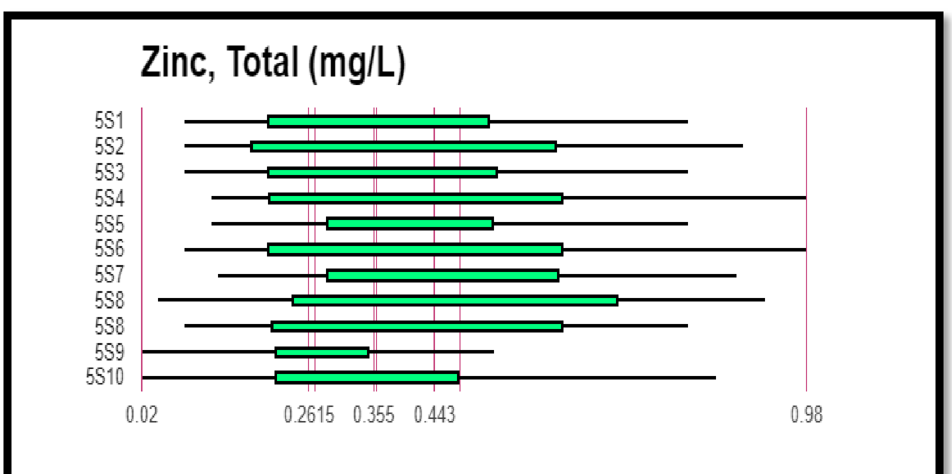


Figure 8



Seasonal and cyclic variations are short-term fluctuations that occur on a regular basis. All of the analyzed parameters were favorably influenced in the first half of the storm water year, except Pb, which accounted for 64% of the overall variation. The first of the year's second component, Fe, N+N, and P, explained 21% of the overall variation, with Fe, N+N, and P being the most prominent. The first component explained 23% of the variation in the second half, whereas the second component explained 21% (Figures 9 and 10). Stormwater quality may vary seasonally due to environmental factors such as the amount, length, and intensity of precipitation.

Figure 9

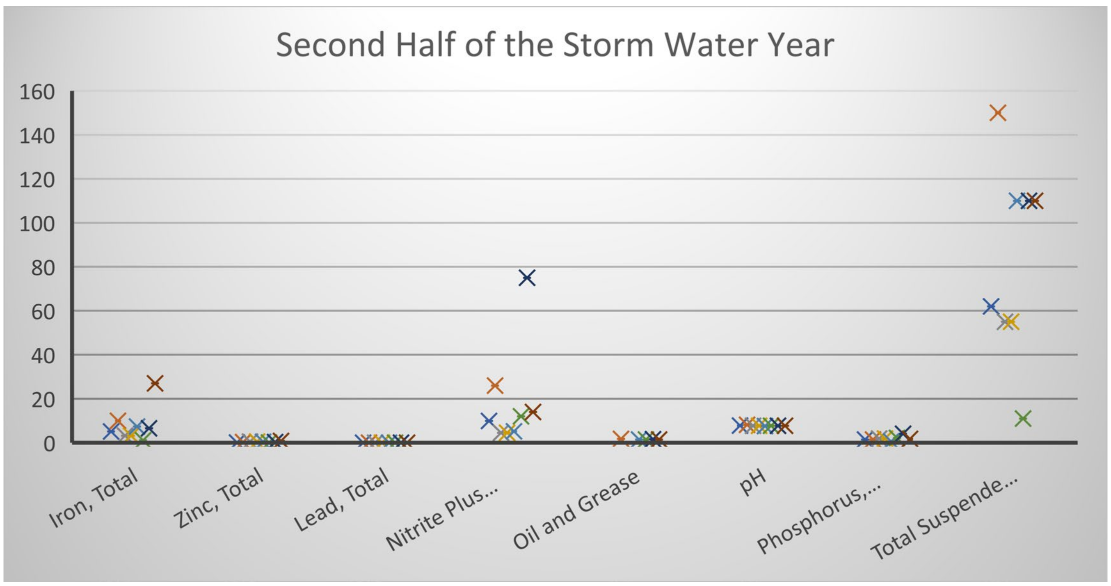
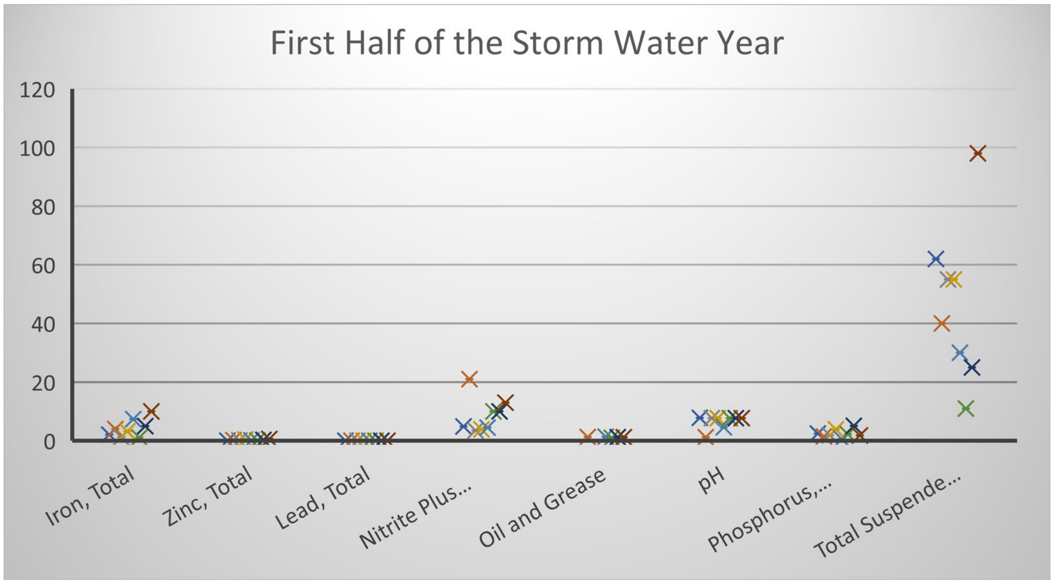


Figure 10



CONCLUSION

Additional screening, including facility evaluations, is required to fully illustrate the correlation of the concentration of different parameters (Salehi 2020). However, conducting the facility visit was not feasible and was outside the scope of this final project. Aerial photographs, digital imagery, and maps found in the facility's Stormwater Pollution Prevention Plans (SWPPPs) were evaluated in lieu of the site visit. In addition, the facility's Stormwater Pollution Prevention Plans (SWPPPs) were analyzed to determine potential pollutant sources, Best Management Practices (BMPs), and monitoring locations.

Systematic stormwater sampling is advantageous because it produces more trustworthy data. However, due to the small number of water samples collected over such a short period of time, knowledge of seasonal and temporal variations in pollutant loadings in surface waters is restricted (Salehi 2020). The greater concentration of pollutants was discovered in stormwater after a lengthy dry period (Lucke 2015). PCA computations were used to examine the seasonal variations in stormwater quality. In comparison to the first half the stormwater season, the second half was found to be poorer. PCA also demonstrated the heavy metals and NPK Compound Fertilizers are mainly associated with types of studied facilities.

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