Enhancing Urban Watershed Resilience: Addressing Environmental Challenges in Newark

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Introduction

The study addressed pressing environmental challenges in Weequahic Lake, Newark, NJ, a region grappling with pollution, socio-economic disparities, and ecological degradation stemming from its industrial legacy. Key problems investigated include pollution from microplastics, nutrient loading, and stormwater runoff, which disproportionately impact underserved communities and threaten public health. The hypothesis tested whether the implementation of Green Engineered Mulch (GEM)-retrofitted rain gardens, combined with targeted public policy interventions, could effectively reduce pollutants, improve water quality, and enhance community resilience.

Public policy played a critical role in shaping the research objectives, emphasizing infrastructure investments, regulatory changes, and community engagement. By incorporating the Area Resilience (ARez) metric, the study aimed to evaluate the interplay between environmental interventions and policy measures in reducing vulnerabilities and enhancing recovery from environmental stressors. This project was essential for exploring how innovative technologies and optimized public policies can collectively address environmental injustices and foster sustainable urban resilience

Objectives

Develop and Implement Restoration Plans: Create comprehensive watershed restoration and protection plans to address pollution and improve the ecological health of Weequahic Lake.
Reduce Pollutants: Utilize Green Engineered Mulch (GEM)-retrofitted rain gardens to decrease nutrient loading, microplastics, and other contaminants in stormwater runoff.
Incorporate Public Policy: Explore the role of public policy, including regulatory changes, infrastructure investments, and community engagement, in enhancing environmental resilience.
Enhance Community Resilience: Employ the Area Resilience (ARez) metric to identify vulnerabilities and improve the capacity of ecosystems and communities to recover from environmental stressors.
Promote Environmental Justice: Prioritize underserved communities disproportionately affected by pollution by engaging residents in education and sustainability efforts.
Foster Sustainable Urban Development: Integrate green infrastructure solutions and public policy to create a scalable framework for urban areas facing similar challenges.

Methods

This study utilized a two-phase approach: developing watershed restoration plans and implementing Green Engineered Mulch (GEM)-retrofitted rain gardens across three urban sites in Newark, NJ. The sites included low-density residential, commercial, and high-density residential areas, allowing for diverse pollutant analysis. GEM technology, designed to filter pollutants such as phosphorus and microplastics, was integrated into rain gardens, with its effectiveness monitored using advanced techniques like FTIR and Raman Microscopy. Sediment and stormwater samples were collected during multiple events to assess pollutant reduction and water quality improvement.

Community engagement was central to the project, involving workshops, town halls, and training sessions to align the solutions with local needs. Guided by the Clean Water Act and NJDEP guidelines, the study evaluated how public policies, and green infrastructure could work together to improve resilience. The Area Resilience (ARez) metric was employed to measure the impact of these interventions on reducing vulnerabilities and enhancing recovery from environmental stressors.

Results and Discussion

The implementation of GEM-retrofitted rain gardens significantly reduced pollutants, particularly phosphorus and microplastics, in stormwater runoff. Analysis of Total Maximum Daily Load (TMDL) data revealed that urban runoff was the primary contributor to pollution, with higher concentrations observed near stormwater inlets. GEM technology effectively retained microplastics, especially larger particles, and reduced nutrient levels, aligning with regulatory water quality goals.

The results demonstrated that green infrastructure could address both the volume and quality of stormwater, highlighting the potential of GEM technology to enhance urban water management. These findings align with broader research advocating for bioretention systems to mitigate urban runoff pollution. However, challenges such as the long-term sustainability and maintenance of GEM systems remain, necessitating further study.

Conclusion

This research highlights the effectiveness of rain gardens as a sustainable solution for reducing microplastic pollution and managing urban stormwater runoff, with a focus on Newark, NJ. The findings demonstrate that rain gardens effectively retain microplastics, particularly near stormwater inlets and in high-density areas, while emphasizing the importance of site-specific design and ongoing maintenance.

By addressing microplastic pollution and urban runoff, this study provides a framework for implementing green infrastructure in other urban areas, supporting sustainable urban development. The results underscore the need for innovative solutions and collaborative efforts among policymakers, urban planners, and engineers to enhance the resilience of urban ecosystems.

PROOF OF CONCEPT/ EXPERIMENT/SIMULATION

Above is a picture of other members of the team and I driving the ROV in Lake Weequahic upstream while collecting raw data

Weequahic Downstream 1 July 15 2024

Date/Time	Temp(C)	Pres(PSI)	Depth(ft)	CNDCT(μS/cm)	SPCNDCT(μS/cm)	R(ohm-cm)	SA(PSU)	TDS(ppt)	WatrDen(g/cm3)	BaroPres(mmHg)	pH(pH)	pH(mV)(mV)	ORP(mV)	DO(con)(mg/L)	DO(%sat)(%Sat)	Turbidity(NTU)	PPO2(Torr)	ExtV(V)	Batt Perc(%)
7/15/2024 2:25:29 PM	32.1714	0.0104017	0.128655	0	0	1E+07	0	0	0.994975	758.432	0	-823.164	-628.589	7.37005	101.405	0.856504	153.444	0.18	68
7/15/2024 2:25:40 PM	32.2077	0.00971794	0.134586	0	0	1E+07	0	0	0.994964	758.395	0	-786.858	-526.413	7.35496	101.264	0.847443	153.208	0.18	68
7/15/2024 2:25:51 PM	32.5445	0.771724	2.11686	822.367	718.789	1216	0.353414	0.467213	0.99512	758.627	0	-937.018	-684.298	10.2617	142.312	13.2686	215.175	0.18	68
7/15/2024 2:26:03 PM	31.784	1.40638	3.22681	825.108	730.459	1211.96	0.359511	0.474798	0.995368	758.575	0	-819.435	-854.429	13.1649	180.27	486.883	273.13	0.18	68
7/15/2024 2:26:14 PM	31.4618	1.28002	3.33896	875.018	778.888	1142.83	0.384336	0.506277	0.995488	758.365	0	-751.3	-871.147	11.9199	162.402	1148.48	246.203	0.18	68
7/15/2024 2:26:25 PM	31.4037	1.15043	3.27184	897.827	799.981	1113.8	0.395159	0.519987	0.995515	758.335	0	-726.399	-853.003	10.4847	142.722	814.673	216.393	0.18	68
7/15/2024 2:26:37 PM	31.4055	1.15407	3.27994	892.706	795.393	1120.19	0.392806	0.517006	0.995512	758.387	0	-681.253	-834.54	9.38272	127.714	328.432	193.652	0.18	68
7/15/2024 2:26:48 PM	31.3973	1.30345	3.3071	896.816	799.167	1115.06	0.394743	0.519459	0.995516	758.432	0	-663.633	-807.279	9.04387	123.078	272.415	186.638	0.18	68
7/15/2024 2:26:59 PM	31.3136	1.14342	3.26257	909.179	811.339	1099.89	0.401006	0.527371	0.995547	758.372	0	-649.433	-781.378	8.54147	116.09	639.478	176.066	0.18	68
7/15/2024 2:27:11 PM	31.3259	1.11844	3.20297	880.501	785.583	1135.72	0.387792	0.510629	0.995534	758.342	0	-636.864	-768.989	7.95415	108.127	579.938	163.976	0.18	68
7/15/2024 2:27:22 PM	31.6501	0.801048	2.0834	805.716	714.91	1241.13	0.351603	0.464692	0.995405	758.297	0	-694.222	-716.056	9.97956	136.389	177.65	206.642	0.18	68
7/15/2024 2:27:33 PM	31.8349	0.913233	2.11701	806.631	713.488	1239.72	0.350845	0.463767	0.995345	758.372	0	-705.352	-667.552	13.2862	182.13	104.229	275.831	0.171	68
7/15/2024 2:27:45 PM	31.8965	0.860606	1.9077	819.749	724.337	1219.89	0.356366	0.470819	0.99533	758.297	0	-692.863	-619.506	15.1034	207.284	37.2669	313.841	0.171	68
7/15/2024 2:27:56 PM	31.8957	0.869495	2.02552	819.479	724.108	1220.29	0.356249	0.47067	0.99533	758.395	0	-684.104	-598.925	15.8754	217.846	44.1168	329.879	0.171	68

The data suggests Lake Weequahic is impacted by pollution, with high conductivity, TDS, and turbidity indicating runoff and sediment issues. While pH and oxygen levels are acceptable, elevated temperatures and turbidity suggest risks of eutrophic conditions and algal blooms.

Community Benefit

This project improved water quality in Weequahic Lake and reduced pollution, directly benefiting underserved communities in Newark, NJ. By addressing urban flooding, air quality, and the urban heat island effect, it enhanced local living conditions. The project also prioritized environmental justice, engaging residents through educational workshops and fostering sustainable practices. These efforts created a healthier, more resilient community while empowering residents to address future environmental challenges.

Future Plans

Future research will expand data collection to include seasonal sampling of stormwater and sediment to evaluate GEM-retrofitted rain garden performance under varying conditions. Long-term monitoring will assess pollutant removal efficiency, microplastic retention, and GEM saturation over multiple years. Additional studies will explore the application of GEM technology in other green infrastructure systems, such as bioswales and constructed wetlands, by analyzing site-specific factors like soil composition, hydrology, and vegetation.

Questions for Discussion

What additional pollutants should be prioritized for monitoring to improve green infrastructure effectiveness?
How can data collection methodologies be standardized to ensure consistency across multiple urban sites?
What are the best strategies for incorporating community-generated data into future green infrastructure planning?

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