Solid Waste Solutions with CDS Technology in Advancing Urban Stormwater Management

by:

Mr. Yale Wong Yah Loo

Managing Director at EcoClean Technology Sdn. Bhd. and Council Member of Association of Environmental Consultants and Companies of Malaysia (AECCOM).

Ir. Ts. Prof. Dr. Teo Fang Yenn

Professor of Water & Environmental Engineering at University of Nottingham Malaysia and Deputy Chair of IEM Environmental Engineering Technical Division.

Dr. Anurita Selvarajoo

Associate Professor at Department of Civil Engineering, University of Nottingham Malaysia.

Continuous Deflective Separation (CDS) technology significantly advances hydrodynamic separation systems of solid waste solutions for urban stormwater management. An extensive review of CDS technology, its working principles, and its advantages over conventional hydrodynamic separators are given in this paper. It emphasises how CDS systems are ideal for managing urban stormwater because they can achieve solid waste and high pollutant removal efficiency, especially when flow conditions are variable, making them highly suitable for urban stormwater management.

We also explore integrating the CDS system with green infrastructure and nature-based solutions to illustrate how a hybrid system can improve the resilience and sustainability of water management. The findings highlight the importance of implementing cutting-edge technology like CDS to handle the escalating solid waste problems associated with urban stormwater runoff in light of climate change and tightening environmental restrictions.

Continuous Deflective Separation (CDS) technology has emerged in recent years, as a frontrunner of solid waste solutions to improve stormwater quality in highly populated areas. CDS technology is now leading the way in stormwater treatment for urban areas. Managing stormwater effectively is a serious challenge in cities, where impervious surfaces and human activities generate significant runoff. This runoff often carries solid waste and pollutants, such as sediment, oils, grease, and debris, all of which can harm water quality and aquatic life.

Traditional solid waste solutions for urban stormwater management, such as gross pollutant traps (GPTs) and hydrodynamic separators, have been widely used. However, these often face limitations due to variable flow conditions, space constraints for installation, and the inability to capture smaller particles in stormwater.

In contrast, CDS technology has revolutionised how we treat stormwater. By using advanced hydrodynamic methods, CDS units can achieve solid waste and higher pollutant removal efficiencies than conventional systems while taking up less space and needing less maintenance. This paper dives into the operational principles, benefits, and applications of CDS technology, highlighting its essential role in modern stormwater management.

Solid-Liquid Separation System

Operating Principle: CDS technology lies in its ability to use gravity and centrifugal force to separate solid wastes and pollutants from stormwater. This system optimises water flow to minimise retention time, allowing for efficient removal of heavy metals, sediments, and other contaminants. As stormwater flows through a CDS unit, a vortex increases water retention time and enhances sediment separation.

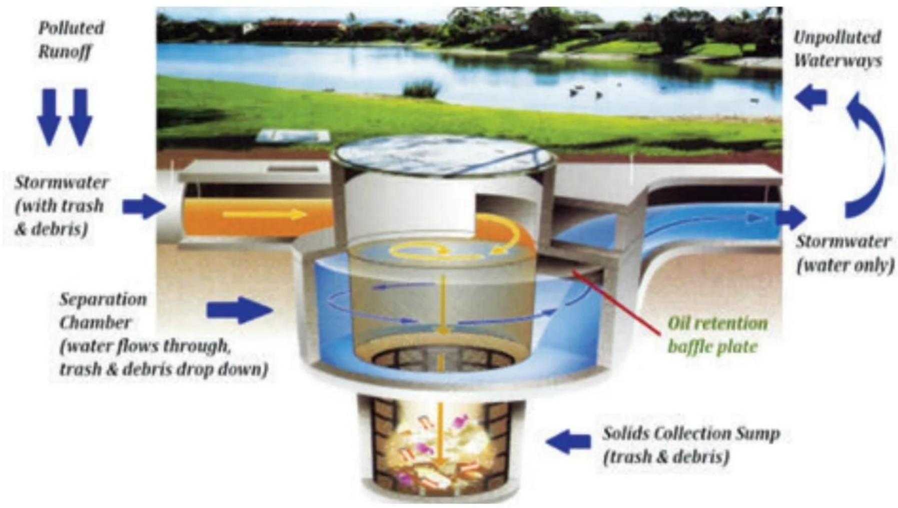

Figure 1: CDS Operation System

In this swirling motion, lighter materials float to the surface or remain suspended, while heavier sediments settle at the bottom. The design utilises advanced micro-hydrodynamics to facilitate effective filtration through a 3-dimensional static screen interacting with the induced flow. This specialised flow helps capture a broad range of particles.

CDS units also incorporate perforated screens and baffles to trap floating debris and oils, improving their ability to remove coarse and fine pollutants. Unlike traditional separators which rely solely on size or density for separation, CDS systems harness hydrodynamic forces to optimise sedimentation and filtration processes.

Essential Elements: One of the standout features of CDS technology is its small installation footprint, making it ideal for urban environments with limited land availability. As cities grow and land becomes more scarce, compact systems are critical. CDS units allow for continuous water flow across a diverse range of treated flows, meaning less water storage is necessary than large cell storage methods.

CDS systems extract significant amounts of contaminants, achieving over 85% removal for fine particles and 96% for coarse ones. Their flexibility allows them to function effectively across varying rainfall cycles and runoff levels. This adaptability makes CDS a reliable, space-efficient solution for managing urban stormwater in the face of changing weather patterns.

Applications: The application of CDS technology presents numerous benefits in urban stormwater management. These systems are particularly efficient at matching street and highway runoff, making them suitable for roadway drainage. This capability is invaluable to urban planners, helping minimise the environmental impacts often accompanying conventional drainage methods.

Industries can also use CDS systems to treat stormwater contaminated with oil, grease, and sediments. As urban areas face increasing regulatory scrutiny over stormwater discharges, adopting technologies such as CDS can ensure compliance while maintaining ecological integrity. Additionally, CDS systems provide reliable runoff control in densely populated residential areas, effectively reducing localised pollution levels and flash flooding risks.

CDS technology fits seamlessly into green infrastructure projects. This integration is essential in contemporary urban design, especially as cities seek to embrace sustainability principles.

Competitive Advantages of CDS Technology

Conventional Hydrodynamic Separators (HDS): Traditional HDS systems rely on size or density-based methods to filter contaminants from stormwater. While effective for capturing larger particles, it is often a struggle with finer sediments and dissolved pollutants. High flow rates can create turbulence, resuspending settled sediments and significantly diminishing their overall performance in handling variable flow conditions.

Gross Pollutant Traps (GPTs): Building on conventional HDS technology, proprietary hydrodynamic separators have evolved into what we now refer to as GPTs. These systems frequently capture large debris and coarse pollutants, e.g. leaves and litter, before reaching water bodies. Typically, GPTs consist of chambers where stormwater passes through screens or meshes that trap larger particles while allowing water to flow through. However, GPTs become less efficient for capturing finer particles, requiring complementary treatment technologies to achieve the desired water quality.

Hydrodynamic Vortex Separators (HDVS): HDVS are an improvement over traditional HDS systems, utilising vortex movement to enhance sedimentation. These systems can maintain better removal efficiencies under moderate flow conditions, capturing smaller particles more effectively than older systems. However, their design typically demands larger footprints than CDS units, and their performance may decline during significant flow fluctuations, limiting their applicability in highly variable stormwater conditions.

Continuous Deflective Separation (CDS): Drawing inspiration from HDVS principles, CDS technology incorporates the latest design innovations to enhance solid waste and pollution removal. The stability of CDS systems makes them reliable options for urban stormwater treatment, mainly due to controlled vortex flow and their ability to handle changing flow conditions. Furthermore, CDS solutions are often economically viable for urban developers looking to upgrade their stormwater treatment capabilities while minimising space and maintenance needs.

CDS technology addresses the shortcomings associated with HDS, GPT, and HDVS by capturing a wider range of pollutants, including coarse and fine sediments and oils. The vortex flow in CDS creates optimal sedimentation conditions, allowing heavier particles to settle effectively. Meanwhile, the perforated screens and baffles ensure that floating debris and oils are contained and trapped without bypassing the system. This holistic treatment approach results in high efficiency for urban stormwater management.

CDS Benefits & Performance: Table 1 shows the key aspects such as pollutant removal efficiency, operational mechanisms, and cost considerations and illustrating the advantages of CDS for modern urban water management.

Table 1: Comparison between conventional separator, HDVS and CDS

Attributes	Conventional HDS & GPT	HDVS	CDS
Pollutant Removal Efficiency	Moderate (20-30%)	High (70-80%)	Very High (85-98%)
Mechanism of Operation	Size/density-based	Vortex flow with size-based	Controlled vortex with deflection
Performance Under Variable Flow	Reduced efficiency	Improved, but may struggle	Maintains high efficiency
Space Requirements	Large footprint	Compact design	Very compact
Maintenance Requirements	Moderate, clog-prone	Lower maintenance	Low; designed to minimise clogging
Initial Investment Cost	Typically, lower	Moderate	Potentially higher, but cost-effective over time
Integration with Existing Systems	May require significant modifications	Can be retrofitted into some systems	Easily integrated with minimal disruption
Environmental Impact	Limited scope	Good for fine sediment	Comprehensive approach

CDS technology offers a variety of advantages, including higher pollutant removal rates and consistent performance even under variable flow conditions. These features make CDS an appealing choice for urban stormwater management, particularly in areas with limited space, and where water quality is a critical concern.

A key feature of CDS technology is its patented non-blocking design which ensures constant flow rates through the screens. This self-cleansing ability makes CDS a more effective option than standard trash screens. According to the Law of Diminishing Returns, when the flow is obvious, the filtration efficiency reaches maximum levels, while a completely blocked screen results in zero efficiency. Therefore, traditional GPTs yield a maximum efficiency of only about 50%. Moreover, in systems where screens double as storage sumps, only 50% of that storage is typically utilised, reducing the average efficiency to 25%. Comparatively, the performance of CDS units can be estimated to be four times more effective under similar treatment conditions.

CDS units are designed to capture pollutants below the screen chamber in a separate sump. These units are primarily installed offline, set up to capture and treat a specified flow rate of 95% for an Average Recurrence Interval (ARI) of three months while allowing for bypass when total flow exceeds that. The bypass flow is engineered to correspond with the maximum drainage flow rate, preventing upstream impact and flash flooding risks compared to in-line GPTs.

Notably, CDS is the only technology analysed using established hydraulic formulas related to the sizing of diversion chambers and culvert considerations. This allows for effective design of the weir length without causing disruptions to drainage infrastructure.

Independent laboratory tests conducted in various countries show that CDS technology captures nearly all sediments down to a size of 0.25 mm. Field data over 20 weeks reveal that almost 30% of the particles are larger than 0.075 mm. In Malaysia, CDS units sold since the inception of Putrajaya Holding have consistently met the Total Suspended Solids (TSS) removal standard of a minimum of 60%. Later revisions to the Malaysian Urban Stormwater Manual (MSMA2) established this minimum TSS standard. CDS has demonstrated its ability to trap over 85% of particles at a size of 0.1 mm.

Integrating Natural and Technological Solutions

Opportunities for Integration: Merging natural and technical approaches in stormwater management presents immense potential for improved treatment and sustainability outcomes. Nature-based solutions (NbS) include constructed wetlands, vegetated swales, and permeable pavements. For example, integrating natural adsorbents such as biochar and/or media bed, and biofilm can boost pollutant removal rates when used alongside traditional stormwater solutions and CDS technology.

Case Studies: Several eye-opening case studies highlight the effectiveness of hybrid systems which CDS technology with natural treatments. In 2016, a project was carried out to improve water quality in Port Dickson's historical area, from a Water Quality Index (WQI) of Class 5 to Class 3 without electricity. This initiative utilised four CDS units for filtration. This process allowed the effluent to undergo further polishing through multiple stages of biofilm and media bed treatment, ultimately achieving the desired improvement in water quality.

In addition, the implementation of an underground sullage water treatment plant in Kuala Lumpur as part of the KL River of Life Phase 2 Project was targeted to achieve Class 2B water quality but it exceeded expectations by reaching Class 2A. A new generation of Hybrid CDS-Lamella clarifiers was incorporated into this project, marking a significant evolution in the final treatment stage.

More recently, a pilot study exploring the synergies between a CDS filtration system, wetland grass and biochar, indicated that stormwater could be treated to meet Class 2B standards by relying solely on kinetic energy sources instead of using electricity. These achievements underscore the potential of hybrid systems to tackle complex urban stormwater management challenges.

Conclusion

CDS technology significantly advances hydrodynamic separation methods of solid waste solutions for urban stormwater treatment. It provides practical solutions to urban pollution problems. While GPTs and traditional separators have limitations, CDS units offer a comprehensive treatment package that captures a wide range of pollutants while requiring minimal footprint and maintenance.

The integration of CDS technology with natural treatment systems and green infrastructure enhances its ability to meet the challenges posed by urban stormwater management. Innovative solutions such as CDS will be key to making urban water management more sustainable and resilient as cities grow amidst climate change. By effectively improving water quality and reducing environmental impacts, CDS technology aligns with broader ecological goals of minimising pollutant discharges to waterways and protecting vital aquatic ecosystems. ■

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