Identification of cost-effective opportunities for addressing pollutants from industrial catchments

Strategic alignment

Regional Performance Objectives

RPO 17: Water quality in waterways and bays is improved by reducing inputs of sediment and other pollutants from urban construction and development.

RPO 24: Risk-based programs are in place to mitigate sources of urban pollution (licenced and unlicensed discharges) to protect bays and waterways.

Key Research Areas

Stormwater management and flooding: Understanding the costs and benefits of various stormwater management interventions for biodiversity, amenity and recreational outcomes.

Water Quality: Developing tools and approaches to assist in strategic planning of pollution management to protect biodiversity, amenity and recreation in waterways across the region.

Summary

There is growing evidence that industrial areas contribute more pollutants to local waterways than other land-uses (such as residential areas) (Sharley et al. 2017). Numerous sources of pollutants arise from industrial areas via direct runoff into stormwater drains, poor onsite practices, accidental spills, illegal dumping, illegal drainage connections or damaged infrastructure. Common pollutants from industrial areas include heavy metals, hydrocarbons, oil and grease, sewage, solvents, detergents, and pesticides.

Regulation, prevention and reduction of pollution within industrial estates can be costly and challenging. Current practices to capture and prevent pollutants entering receiving waterways include structural isolations, e.g., bunding, on-line treatment, e.g., gross pollutant traps (GPTs), regulatory compliance, enforcement, behaviour change programs and incentive schemes. This project focuses on evaluating current practices, both within Australia and globally for addressing pollutants from industrial catchments. The project also aims to understand the most effective ways to reduce pollution from industrial estates in Greater Melbourne by trialling various treatment and control options.

The project is expected to increase confidence in the management of stormwater in industrial catchments, support management planning and help to support the achievement of the Healthy Waterways Strategy objectives relating to improved water quality in industrial areas.

Industrial estates can be a major point sources of pollution, identified as the most polluting land use for receiving waters. Our research shows that the performance of stormwater wetlands in industrial areas may be compromised by the level and range of catchment pollutants they receive. This leads to potentially high sediment disposal costs when wetlands need to be reset. A main recommendation is for protection and improved management needs to be incorporated into Stormwater Guidelines.

The most successful practices for industrial estate management are a multi-faceted approach, focusing on small to medium businesses, that combines a mix of non-structural and structural stormwater strategies, e.g., compliance, education, source and end of pipe solutions and is not a "one size fits all" approach, but needs to be tailored.

Recommendations

- Evaluate opportunities to treat dry weather and first flush pollution from a storm event in a 'treatment facility' at the end of industrial estates.
- Evaluate effectiveness of a multi-faceted approach as a case study.
- Design of new industrial estates to consider a pilot on-line treatment facility.
- Champion the incorporation of online stormwater drain treatment options into EPA Victoria's stormwater management guidelines.

What did we do?

Literature Review

The literature review evaluated current practices, both within Australia and globally, for addressing pollutants from industrial catchments. The strategies included Non-structural Best Management Practices (BMPs) - enforcement, education, incentives and behaviour change, and structural BMPs - structural isolations within buildings, drains and surrounding industrials estates, devised to capture and treat pollutants. The review identified and evaluated the suitability of each type of control option for new and old industrial estates with the Greater Melbourne area in mind.

Online Treatment Solutions

Based on the literature review of potential media, subsequent laboratory trials assessed different media potential to remove pollutants from industrial stormwater. The system featured a closed circulation of artificial stormwater contaminated with Zinc, emulating intermittent stormwater drainage into a filtration column prior to release and recycling. Seven different materials (bluestone, sand, clay pebbles, premium horticulture pumice, agricultural charcoal, vermiculite, pinebark) were tested in the experiment for zinc concentrations and physico-chem parameters and the trial ran for 40 days (11 hours per day, 5 days a week).

Further, batch adsorption experiments were carried out based on OECD guidelines - Test No. 106: Adsorption (OECD 2000) for Silver on materials determined from the previous zinc experiments. Successful materials were then tested in the field within Melbourne Water's Barry Rd on-line stormwater drain Toxicant Treatment Facility (TTF) in Campbellfield.

Table 1. Site locations for industrial sampling 2020/2021

Code	Name	Catchment	Location
321	Stony Creek	Werribee River	West
2203	Francis St	Werribee River	West
2205	Burgess St	Werribee River	West
2206	Fairbairn Rd Drain	Werribee River	West
2204	Cherry Creek	Werribee River	West
80	Lillemur Drain	Yarra	North
93	Bell St MD	Yarra	North
853	Ainslie Rd	Yarra	North
1046	Barry Rd	Yarra	North
1044	Thomastown MD	Yarra	North
877	Merlynston Creek	Yarra	North
2201	Lilydale Drain	Yarra	East
2202	West Eltham MD	Yarra	East

Water Quality Sampling Around Industrial Estates 2020/21

To understand the current state and types of pollutants coming from some of Melbourne's Industrial Estates, water quality and toxicology testing was conducted in 2020 and 2021 (Table 1). The sampling was also designed to understand if there had been a reduction in pollution during COVID-19 restrictions. Water samples were collected weekly during June-August 2020 and March-May 2021 across 13 sites below Industrial Estates and analysed for metals and ammonia.

What did we find?

Literature Review

The most successful practices for industrial estate management are a multi-faceted approach, focusing on small to medium businesses, that combines a mix of non-structural and structural stormwater strategies, and is not likely to be a "one size fits all" approach, but needs to be tailored to the area (Table 2).

Key lessons include:

- Regulation and BMP guidelines are essential to regulate stormwater pollution from industrial estates.
- Enforcement of these regulations are imperative to reduce stormwater pollution from industrial estates.
- Long term policy must promote best practice industrial stormwater management.
- To be effective, non-structural BMPs must incorporate compliance measures, provide incentives, continue active and meaningful engagement and provide continued education, particularly to small and medium businesses.
- Structural isolations should be incorporated when designing new industrials estates or retrofitted in existing industrials estates to reduce stormwater pollution. Small to medium businesses should be the focus.
- There is an opportunity to treat dry weather stormwater and first flush during a storm event runoff through filter material which capture pollutants at the end of catchment (bottom of the industrial estate).
- Biofiltration systems may only be suitable for industrial estates which only have 'low risk' businesses (e.g. businesses that don't use or store chemicals).

Table 2. Strategies that could be implemented to best manage industrial pollution from new and existing industrial estates

Strategies	New Industrial Estate	Existing Industrial Estate
Enforcement	Important to have 'on-the-ground' enforcement/compliance officers to ensure each business is not 'polluting'. Disincentives (penalties) should be applied where appropriate.	
Non-Structural BMPs		
Education	Best management practice guidelines (BMP), tools and information to be provided to businesses within industrial estates (including capacity building/training opportunities). Target: medium to small businesses.	
Incentives	Offer incentives (positive recognition, assistance) to high-risk businesses, particularly medium to small businesses	
Behaviour Change	Conduct regular site inspections to evaluate each business – reinforce and maintain change to best practice. Focus on small and medium businesses.	
Structural BMPs		
Structural isolation within buildings	Design new buildings and estates to incorporate structural controls (bunding, trench gates etc.) within buildings and wash down areas. A trade waste agreement may be required.	Where possible 'retrofit' existing buildings and wash downs areas with structural controls (bunding, trench gates etc.). A trade waste agreement may be required.
Structural isolation	Fit gully baskets, litter traps etc. at the end of industrial estates to remove gross pollutants from entering the receiving waterway.	
Structural isolation	Treat dry weather flows and first flush stormwater runoff through materials which filter and adsorb pollutants – built into the design of the industrial estate.	
Biofiltration systems (should only be considered in 'low risk' industrial estates – will be ineffective in 'high risk' industrial estates)	Install and maintain vegetated strips, buffer strips and rain gardens to prevent diffuse pollution – should be considered when designing a new industrial estate.	In some areas there may be opportunities to install vegetated strips, buffer strips and rain gardens to prevent diffuse pollution within an existing industrial estate.

Online Treatment Solutions

The research examined and differentiated the suitability of various materials to sufficiently remove zinc and silver from solution, based on their physico-chemical characteristics and explain the mechanism of adsorption via kinetic modeling. In summary, blue stone (Bastion), agricultural charcoal (Brunnings) or vermiculite (Brunnings) were more predictable and efficient candidate materials for the removal of Zinc (Figure 1) while charcoal (Green Man Char) and scoria (Brunnings) were determined more suitable for Silver adsorption (Figure 2). Collectively, charcoal or biochar forms may be suitable for the removal of both metals in a mixture, likely due to increased porosity and surface area for available ion interactions, however sediments high in silicate groups (aluminosilicate or silica oxide) also remain a promising selection for the adsorption of heavy metals, due to multiple ion interactions and cation exchange capacity.

The research examined the effectiveness of materials to absorb metals from the TTF at Barry Road. A summary of the research is provided in Table 3. Some small reductions of metals were observed after the runoff was treated through the TTF suggesting that the materials were adsorbing metals. Furthermore, high concentrations of these metals were observed in the fine sediments and materials. In summary volcanic rock, blue stone and charcoal were suitable for removal of metals. However, the materials did not completely adsorb all metals, and some were passing through the treatment facility, which differed from the laboratory trials. A lot of fine sediment passed through the triple interceptor and ended up in the filter material causing clogging and blockages. Improvements in design to reduce the likelihood of clogging and a larger volume of filter material may improve the effectiveness of the TTF. Future experiments should include more frequent water samples measuring both filterable and total metals and sediment samples (filtered material and soil below the outlet).

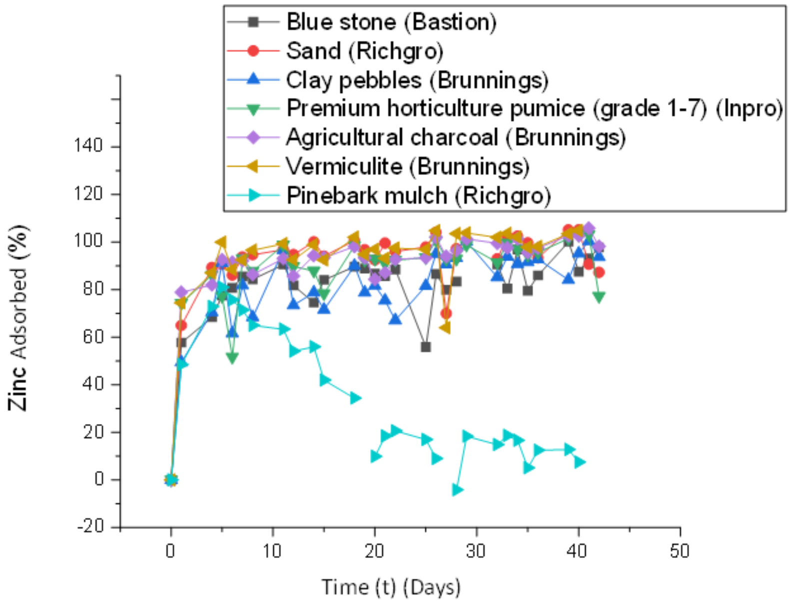

Figure 1. The adsorption of Zinc from artificial stormwater by different materials across time (t) (days).

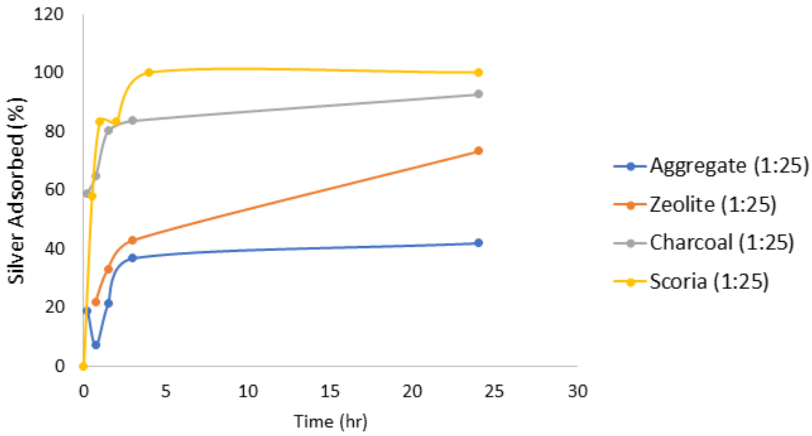

Figure 2. Batch adsorption of silver with different materials over 24 hrs. Silver was dissolved as AgNO3 (approx. 2 ppb) and mixed with aggregate (Bastion), charcoal (Green Man Char), scoria (Brunnings) or zeolite.

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Water Quality Sampling Around Industrial Estates 2020/21

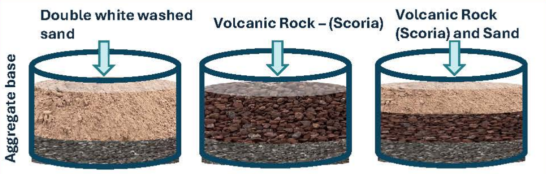
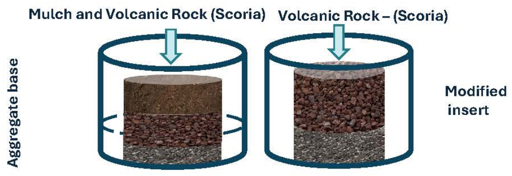
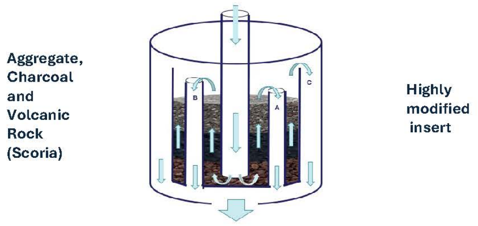
The data highlights that metals and sometimes ammonia and *E.coli* are pollutants of ecological and human health for aquatic recreation concern coming from Industrial areas. Across all sites, copper and zinc were nearly always above the ANZG guideline values (ANZG 2018) and the water was demonstrated to be toxic to test organisms i.e., the non-biting midge *Chironomus tepperi* (except at Merlynston Creek, Lilemur Drain and Lilydale Drain (Table 3)). Silver was occasionally detected at Barry Road and Merlynston Creek and was above ANZG guideline values (2018).

Visible signs of pollutants (litter, odour, oil slicks) and high concentrations of metals, ammonia and *E.coli* were observed during both during and after COVID restrictions, with no clear reduction of pollutants during the restrictions. This data suggests that industrial estates were still operational during restrictions and pollutants were still consistently coming down the drains or that pollutants are derived from legacy sources if industrial activities have ceased or reduced.

Figure 3. A summary of the trials conducted in the Toxicity Treatment Facility at Barry Road – design, results and outcomes.

Future direction and knowledge gaps

- Investigate pollution sources from current industrial activities in Greater Melbourne (metals and *E.coli)* from industrial activities including pollution events at Barry Rd drain and those identified in the 2020/21 study, determine if other key pollutants are also associated e.g., pesticides in water and sediments and determine control options. Work with all authorities (council/ EPA/ MW) is needed to reduce inputs through structural and non-structural practices.
- Optimisation of in-field online treatments (Barry Road), to understand maintenance schedule and costs, reuse and recycling options for online treatment facilities.
- Assess the effectiveness of programs run by Officers for the Protection of the Local Environment (OPLEs) or behaviour change/education in selected industrial areas around Greater Melbourne, investigate investment commitments.
- Continue laboratory trials as needed for testing cost effective materials.
- Test a mixture of metals to understand the absorption using a flow through system of selected material.
- Field trial further test materials to work out optimal maintenance and maximum absorption of heavy metals (site specific).

Design Arrows indicate water pathway	**Results**	**Outcomes**
Test One: Six Weeks May 2022		
	• Some reductions in metals • System no longer works after six weeks – clogging • Actual samples of material were not collected	• Sand potentially too fine • Scoria and aggregate good options • New design to prevent clogging
Test Two: Twelve Weeks Nov 2022		
	• Some reductions in metals • System clogging- layer of fine sediment on top • Materials adsorbing metals • Clean sediments below outfall	• Scoria is a good option • New design to prevent clogging
Test Three: Four Weeks Feb 2023 (still ongoing)		
	• Some reduction in metals • No clogging • Biofilm forming	• Scoria and charcoal continue to be good options • Better design to use at Barry Road

- Trial other online treatment solutions/ designs–Toxicant Treatment Facilities in old and new industrial areas.
- Future experiments should include more frequent water samples measuring both filterable and total metals and sediment samples (filtered material and soil below the outlet).

References/ Reports

ANZG (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.

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Kellar, C., Miranda, A., Hassell, K., Tewman, M. and Pettigrove, V. (2020) Identification of effective and affordable opportunities for addressing pollutants from industrial catchments. Aquatic Pollution Prevention Partnership, Technical Report No. 18, RMIT University, Victoria, Australia.

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Table 3. Summary of water quality and toxicology results collected at 13 industrial estates across Greater Melbourne with an accompanying condition legend table

Site	Chromium	Lead	Copper	Zinc	Nickel	Ammonia	Silver	*E. coli*	Toxicity	Macroinvertebrates	Pollutants of Concern
Stony Creek (321)											Copper, Zinc
Francis St Main Drain (2203)											Copper, Zinc, Ammonia
Burgess St Main Drain (2205)											Copper, Zinc, Ammonia, *E. coli*
Fairbairn Rd Drain (2206)											Copper, Zinc, Chromium, *E. coli*
Cherry Creek (2204)											Copper, Zinc
Ainslie Rd Drain (853)											Copper, Zinc, *E. coli*
Barry Rd Drain (1046)											Copper, Zinc, Silver, *E. coli*
Thomastown MD (1044)											Copper, Zinc
Merlynston Creek (877)											Copper, Zinc, Silver
Lillemur Drain (80)											Copper, Zinc, Chromium, Nickel
Bell St Main Drain (93)											Copper, Zinc, Ammonia, *E. coli*
Lilydale Drain (2201)											Copper, Zinc
West Eltham Main Drain (2202)											Copper, Zinc, Chromium

Condition Legend						
Metals and E.Coli		Below Guideline values (n=16)	Occassionally above Guidelines (n=1-3)	Sometimes above Guidelines (n=4-10)	Majority above Guidelines (n=11-15)	Always above Guidelines (n=16)
Toxicity	Colour gradient indicates the effect of pollution on the organisms	High Survival		High Survival, Effected Growth	Moderate Survival	Low Survival
Macroinvertebrates		Rich	Not sampled			Poor