MICROBIOLOGICALLY INFLUENCED CORROSION (MIC) OF GAS PIPELINES

Causes, detection and integrated mitigation

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Why MIC demands attention

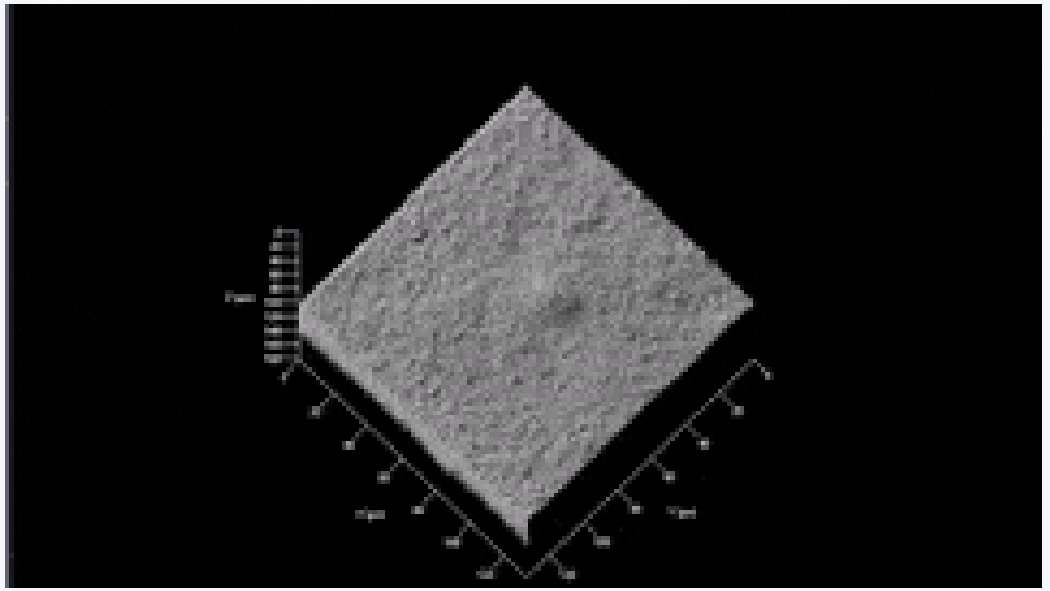
A localised threat that can develop inside technically protected systems

MIC changes the chemistry at the steel surface

- Biofilms create microenvironments that differ sharply from the bulk soil or water.
- Attack can concentrate into pitting, tunnelling and rapid loss of remaining wall.
- Coatings and cathodic protection remain essential, but do not eliminate MIC risk.

Integrity consequence

Leaks • ruptures • environmental harm • disruption



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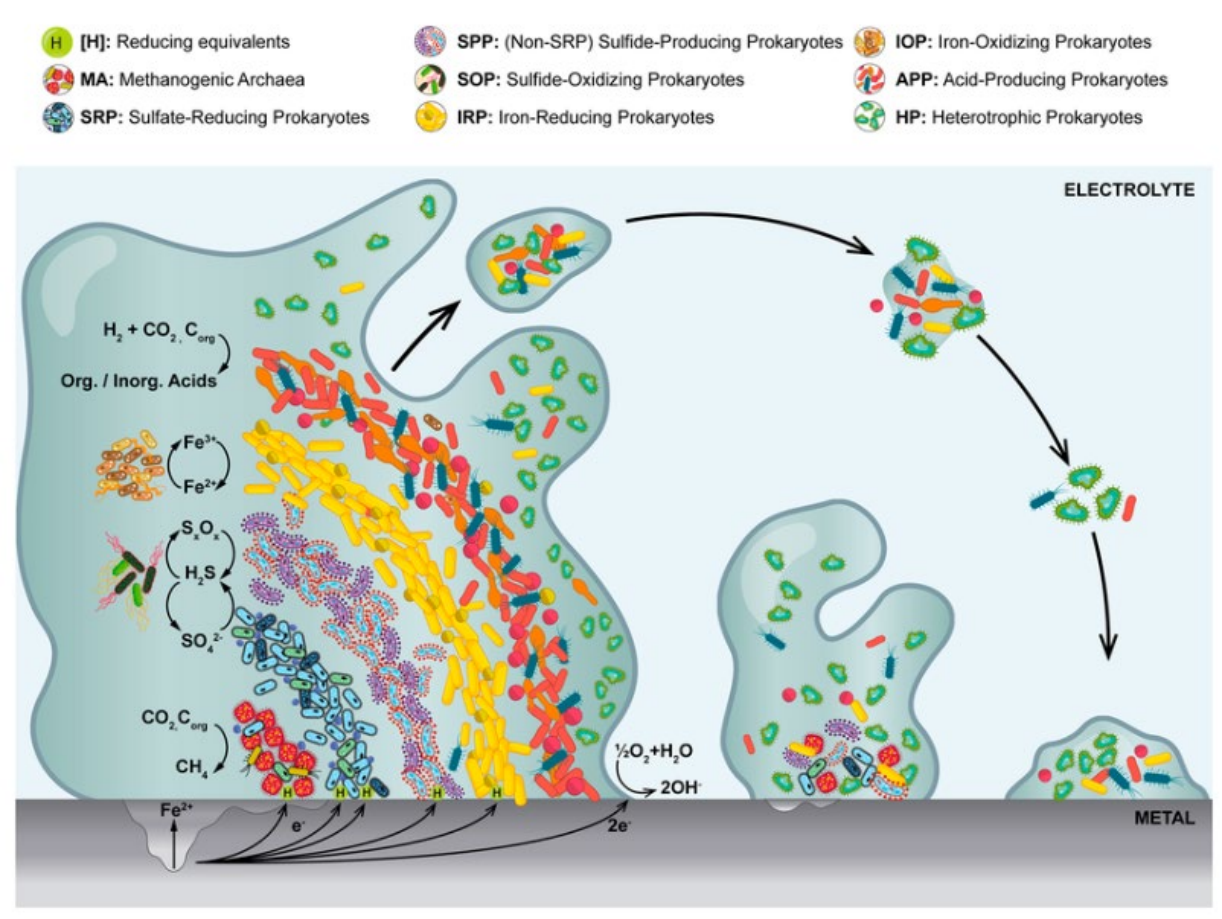
How a corrosive biofilm develops

Colonisation, chemical gradients and electrochemical acceleration



1. **Attachment**

   Microorganisms attach at defects, deposits or disbonded coating.

2. **Biofilm growth**

   Extracellular material traps water, nutrients and corrosion products.

3. **Gradient formation**

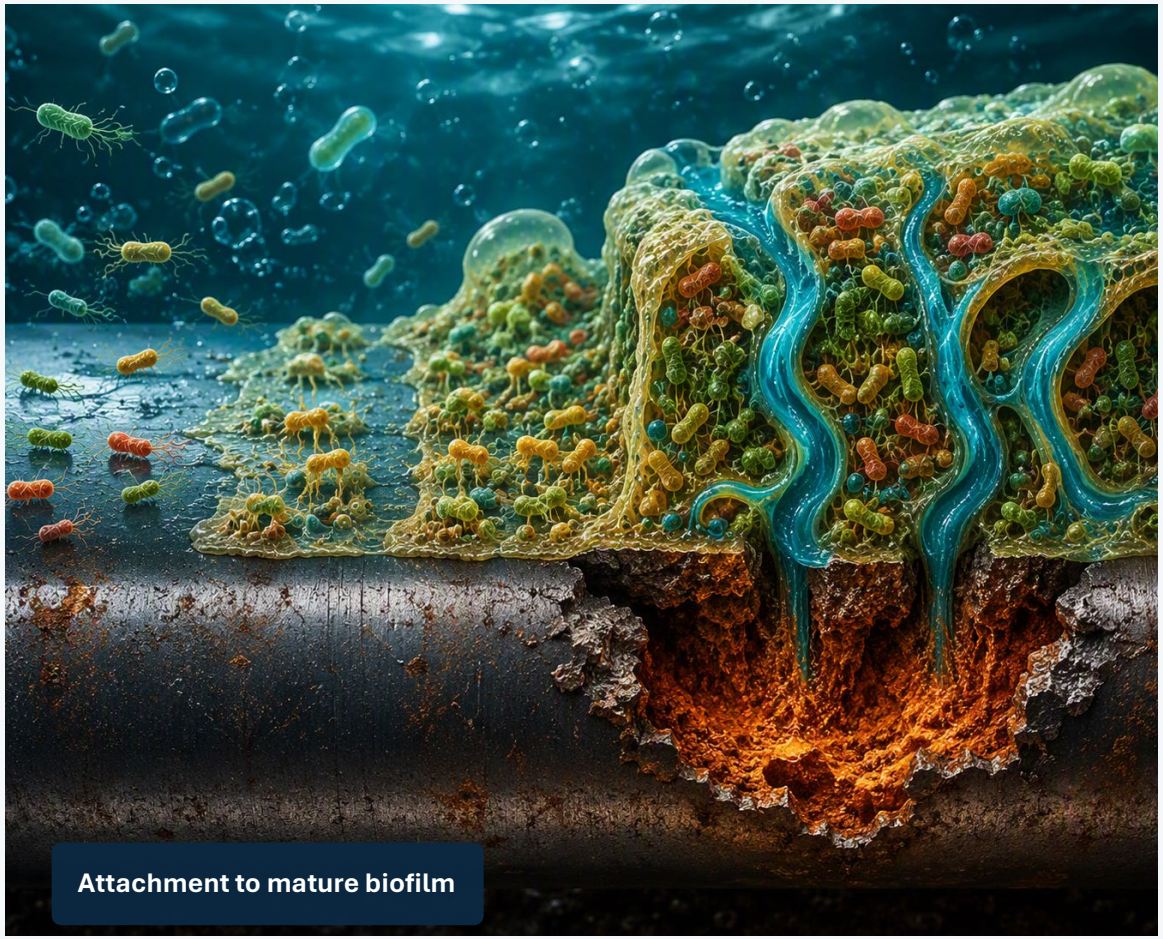
   Oxygen, pH and redox conditions become highly corrosive.

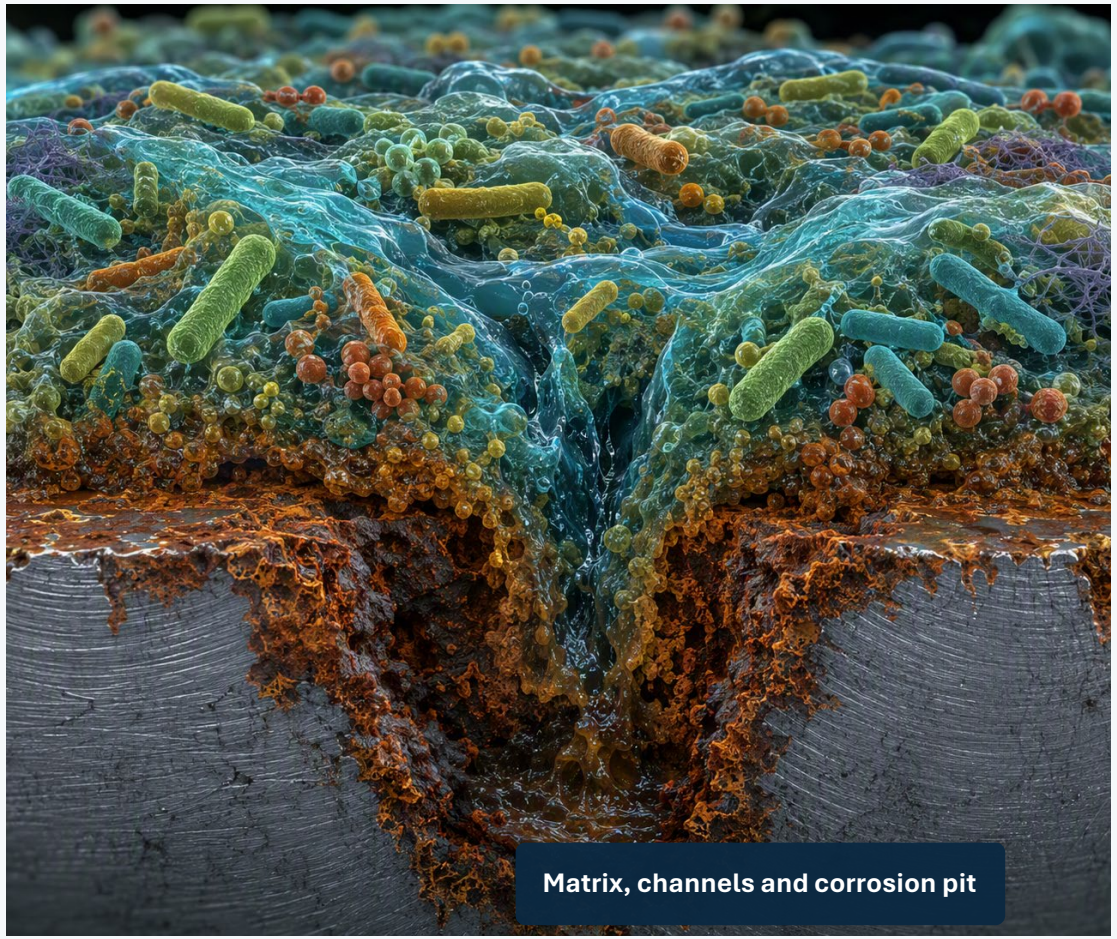
4. **Localised attack**

   Metabolites and electron transfer accelerate steel dissolution.

Biofilm architecture at the steel surface

A protected microbial community creates steep chemical gradients and localised attack





The extracellular polymeric matrix retains water and nutrients, limits transport and sustains distinct microenvironments directly against the steel.

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The microbial consortium

Different functional groups reinforce the corrosive environment

Sulphate-reducing bacteria

Produce biogenic sulphides; strongly associated with anaerobic pitting and localized corrosion.

Acid-producing bacteria

Lower local pH and destabilise protective oxide films.

Iron cycling bacteria

Create deposits, crevices and unstable iron compounds.

Nitrate-reducing bacteria

Generate reactive nitrogen species.

Key idea: MIC is typically a community effect, not a single-organism mechanism.

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Where MIC risk concentrates

The highest susceptibility occurs when barriers fail and moisture persists

1

Coating disbondment

Shielded, low-oxygen niches beneath detached coating.

2

Wet, low-resistivity soil

Clay-rich zones retain water and support long-lived activity.

3

Available nutrients

Organic carbon, sulphate, nitrate and chlorides shape the community.

4

CP interaction

Hydrogen evolution and shielding can alter local microbial behaviour.

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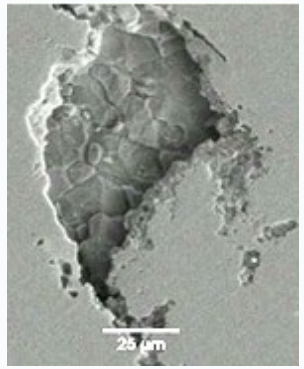
What MIC can look like

Morphology supports the diagnosis, but is not proof on its own

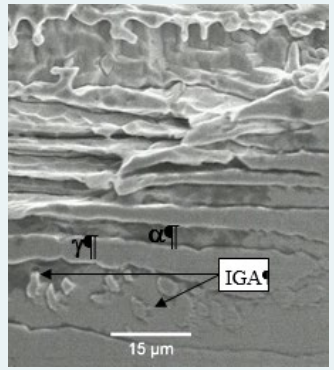
Smooth bowl-shaped pits

Rounded cavities with relatively smooth internal walls.



Intergranular / undercutting

Attack follows grain boundaries or spreads beneath coating.



Honeycomb attack

Adjacent cavities merge into a cellular pattern.

Morphology + microbiology + surface chemistry + environmental context

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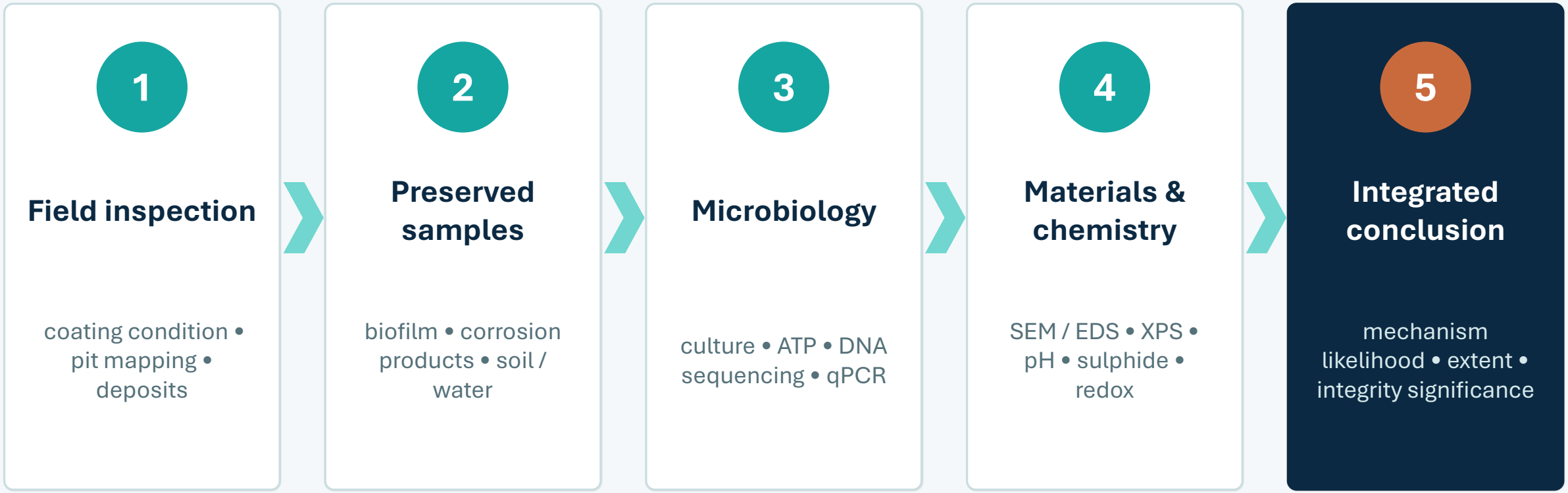
MIC diagnostic workflow

Build evidence from the field, laboratory and operating history



Sampling quality is often the weakest link: collect before cleaning, preserve correctly and maintain chain of custody.

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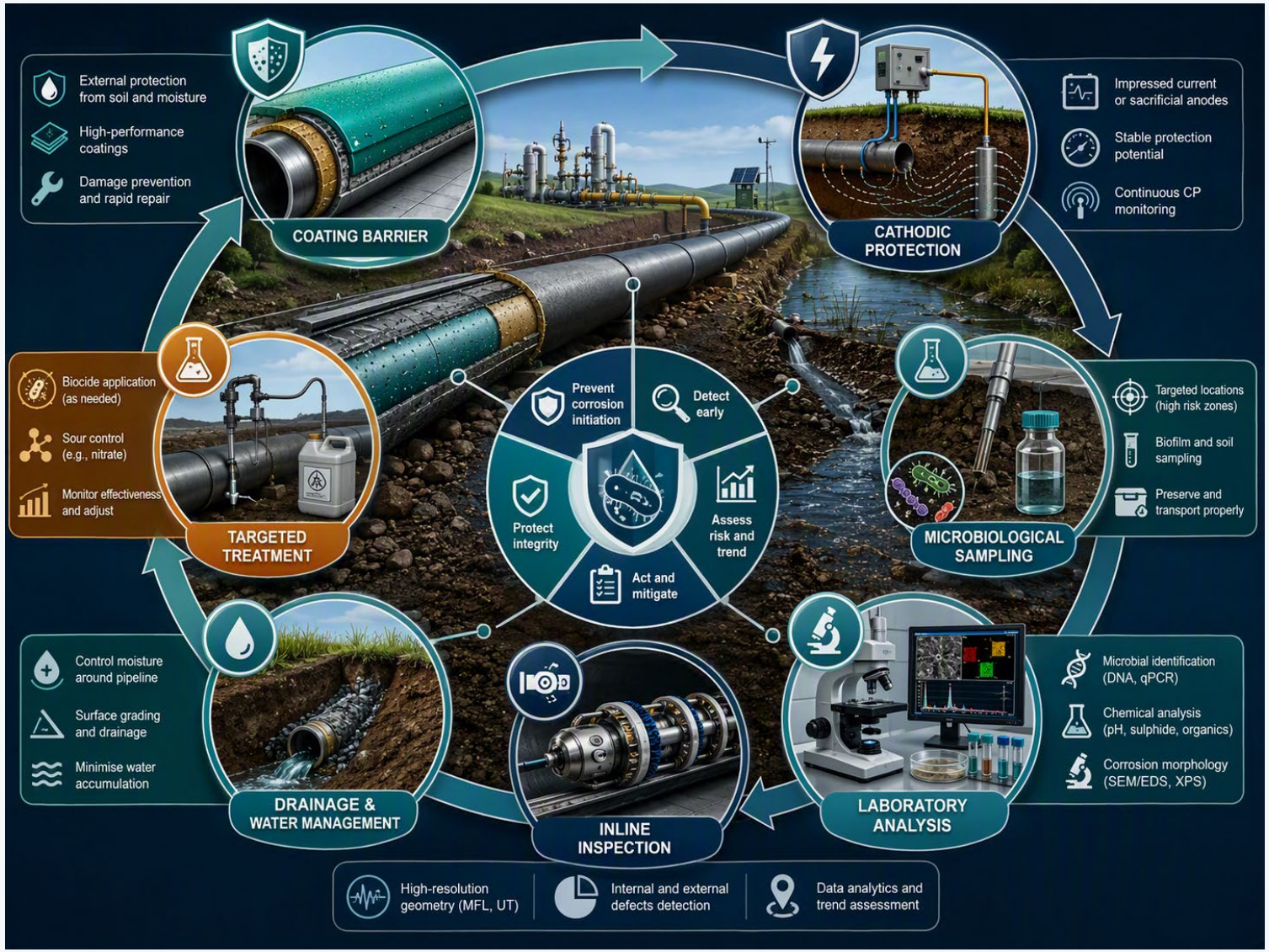
MIC mitigation works as a system

Layer prevention, surveillance and targeted intervention



Prevent	High-adhesion coating, defect control and drainage.
Protect	Optimised cathodic protection without excessive polarisation.
Detect	ILI, CP surveys, soil chemistry and microbial surveillance.
Treat	Targeted biocide or nutrient control where justified.
Learn	Trend data, verify effectiveness and update susceptibility models.

From detection to integrity decision

Prioritise action using evidence and consequence

Evidence strength

- Morphology
- Microbial activity
- Surface chemistry
- Environmental fit

Decision priorities

Immediate

Confirm remaining wall, pressure response and excavation needs.

Near term

Repair coating, address drainage, optimise CP and define treatment.

Ongoing

Trend ILI, microbial indicators and recurrence at susceptible locations.

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THREE TAKEAWAYS

01

MIC is a surface ecosystem

Biofilms create corrosive local chemistry that bulk measurements can miss.

02

Diagnosis requires convergence

Pit shape alone is suggestive, not conclusive. Combine morphology, microstructure, microbiology and chemistry.

03

Control and remediation must be integrated

Coating, CP, drainage, inspection, testing and targeted treatment work together.

Questions & discussion

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