The difference in **microbial activity** depends on **how plant residues are managed**—whether left as mulch on the surface, incorporated into the soil with a rotavator, or uprooted and removed. Let's analyze each case in detail with the **science behind it**:

✔ *Case 1: Mulching with Plant Residue Above Soil Surface*

- Residues remain on top of the soil as **organic mulch**.
- **Microbial Activity Characteristics**:
    - **Dominant microbes**: **Fungi**, actinomycetes, surface-dwelling decomposers (beetles, earthworms).
    - **Decomposition speed**: **Slow to moderate** because oxygen is available but moisture can fluctuate.
    - **Process**: Mostly **aerobic decomposition**, producing **CO_2 and humic substances**.
    - **Carbon-Nitrogen (C:N) balance**: More **carbon retention**, leading to humus formation.
    - **Effect on soil health**:
        - Improves **topsoil structure**.
        - Increases **fungal biomass** → stable organic matter.
        - Prevents rapid nitrogen loss.
        - Encourages mycorrhizal association with roots.

✔ **Benefits**:

- Better for **long-term soil health** and **carbon sequestration**.
- Promotes **natural soil cover**, reducing erosion and temperature swings.
- Mimics **forest ecology**.

✔ *Case 2: Residue Incorporated into Soil by Rotavator*

- Residues are chopped and **mixed inside the soil** by tillage.
- **Microbial Activity Characteristics**:
    - **Dominant microbes**: **Bacteria**, especially decomposers that work in moist, oxygen-limited environments.
    - **Decomposition speed**: **Fast**, due to intimate contact with soil microbes and moisture.
    - **Process**: **Mostly aerobic**, but can become **anaerobic in patches** if too deep or compacted.
    - **C:N ratio impact**:
        - Rapid decomposition may **tie up nitrogen** temporarily (nitrogen immobilization).
    - **Effect on soil health**:

        - Short-term flush of microbial activity (bacterial bloom).
        - Faster nutrient release, but less humus formation compared to surface mulch.
        - Disturbs soil aggregates and earthworm channels due to rotavation.

✔ **Benefits**:

- Quick nutrient cycling for next crop.
- Faster residue clearance.

❌ **Drawbacks**:

- Less **long-term organic matter buildup**.
- Can lead to **soil compaction and microbial imbalance** if repeated frequently.

✅ *Case 3: Uprooting Entire Plant and Removing from Field*

- Both above-ground biomass and roots are **removed from soil**.
- **Microbial Activity Characteristics**:
    - **Dominant microbes**: Limited, mostly those breaking down minor root hairs left behind.
    - **Decomposition speed**: Minimal inside soil because no major residue remains.
    - **Effect on soil health**:
        - Huge **loss of carbon and organic matter**.
        - Reduces microbial diversity and food web activity.
        - Weakens **aggregate stability** and **nutrient retention**.

❌ **Major drawbacks**:

- Soil fertility declines over time.
- Dependency on **external inputs (fertilizers, compost)** increases.
- Soil becomes biologically inactive, moving toward **"dead soil" syndrome**.

✅ Root Zone Role

- **If roots remain in soil (not uprooted)**:
    - **Microbial life thrives** around roots (rhizosphere).
    - Residual roots decompose slowly, feeding **beneficial fungi and bacteria**.
    - Maintains **soil structure and carbon**.
- **If roots are uprooted**:
    - Soil loses key organic material.

- Microbial food sources drastically reduce.

Summary Table

Residue Management	Dominant Microbes	Decomposition Speed	Humus Formation	Soil Health Impact
Surface Mulch	Fungi + Actinomycetes	Slow-Moderate	High	Long-term fertility, stable carbon
Incorporated via Rotavator	Bacteria	Fast	Low-Medium	Quick nutrients, but less humus
Uprooted & Removed	Minimal	Very Slow	None	Soil degradation

👉 **PQNK prefers surface mulch + roots intact** because it mimics **natural forest ecology**, ensuring:

- Stable carbon cycle.
- Strong microbial diversity (fungal-dominant).
- Soil resilience against erosion and climate stress.