Hydrogeology

Sanitation linkages

ACWADAM

Sanitation…

Drainage and disposal/re-use/recycling of household wastewater

Management/re-use/recycling of solid wastes (trash or rubbish)

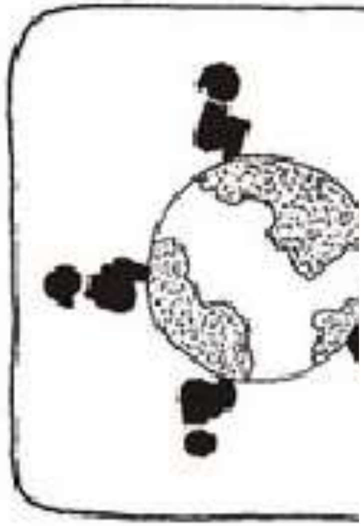
Safe collection, storage, treatment and disposal/re-use/recycling of human excreta (faeces and urine)

Drainage of storm water ; Treatment and disposal/re-use/recycling of sewage effluents

Management of hazardous wastes (including hospital wastes, industrial wastes and chemical/ radioactive and other dangerous substances)

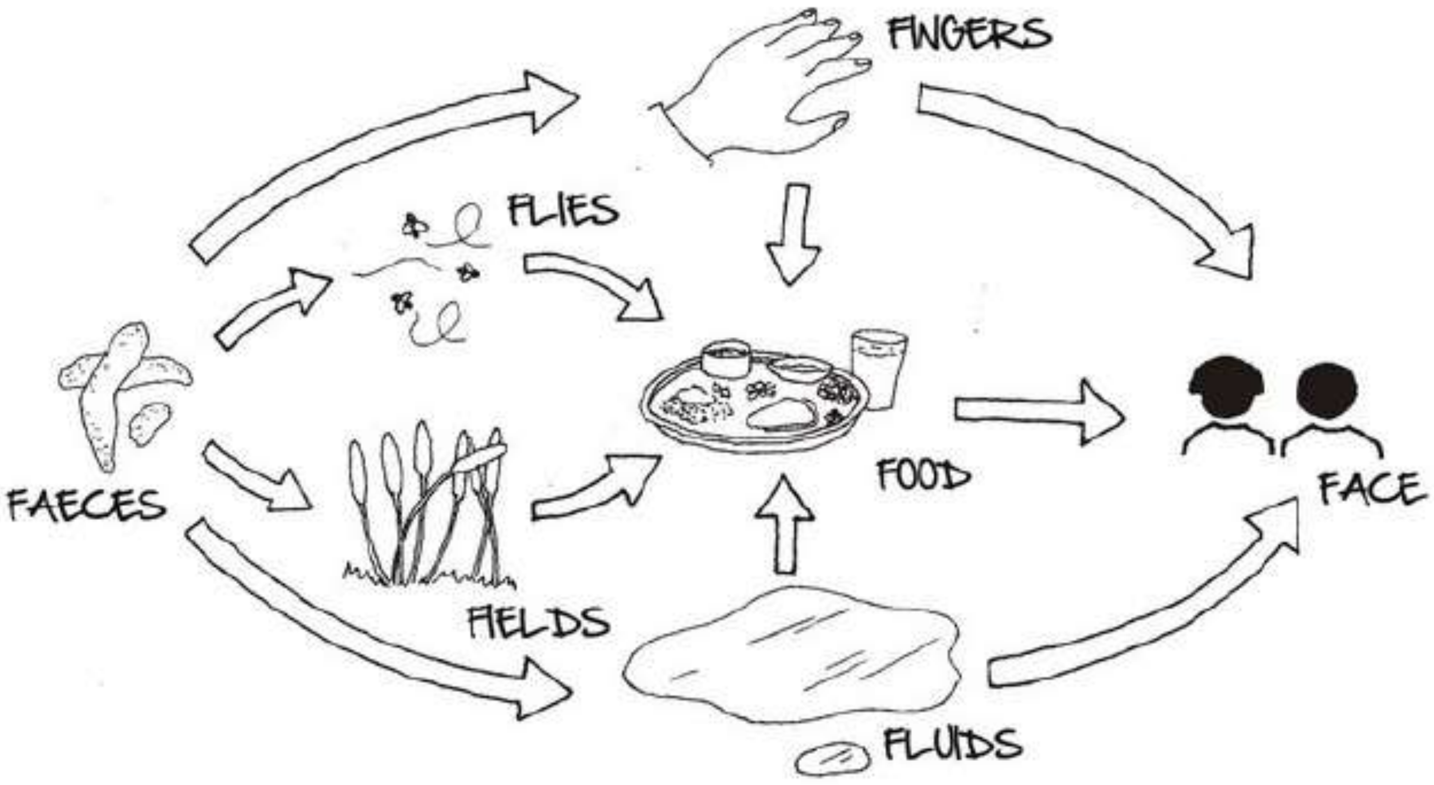
ACWADAM

Source: WHO in cooperation with UNICEF and WSSCC



PeePoo we al

We can contai
diseases by sanitation



The 'F' Diagram: The routes pathogens take to reach us

- have
-ration

n lost
to war!

Fecal contamination

Bacteria

Pathogens

E.coli

Protozoa

Nitrate

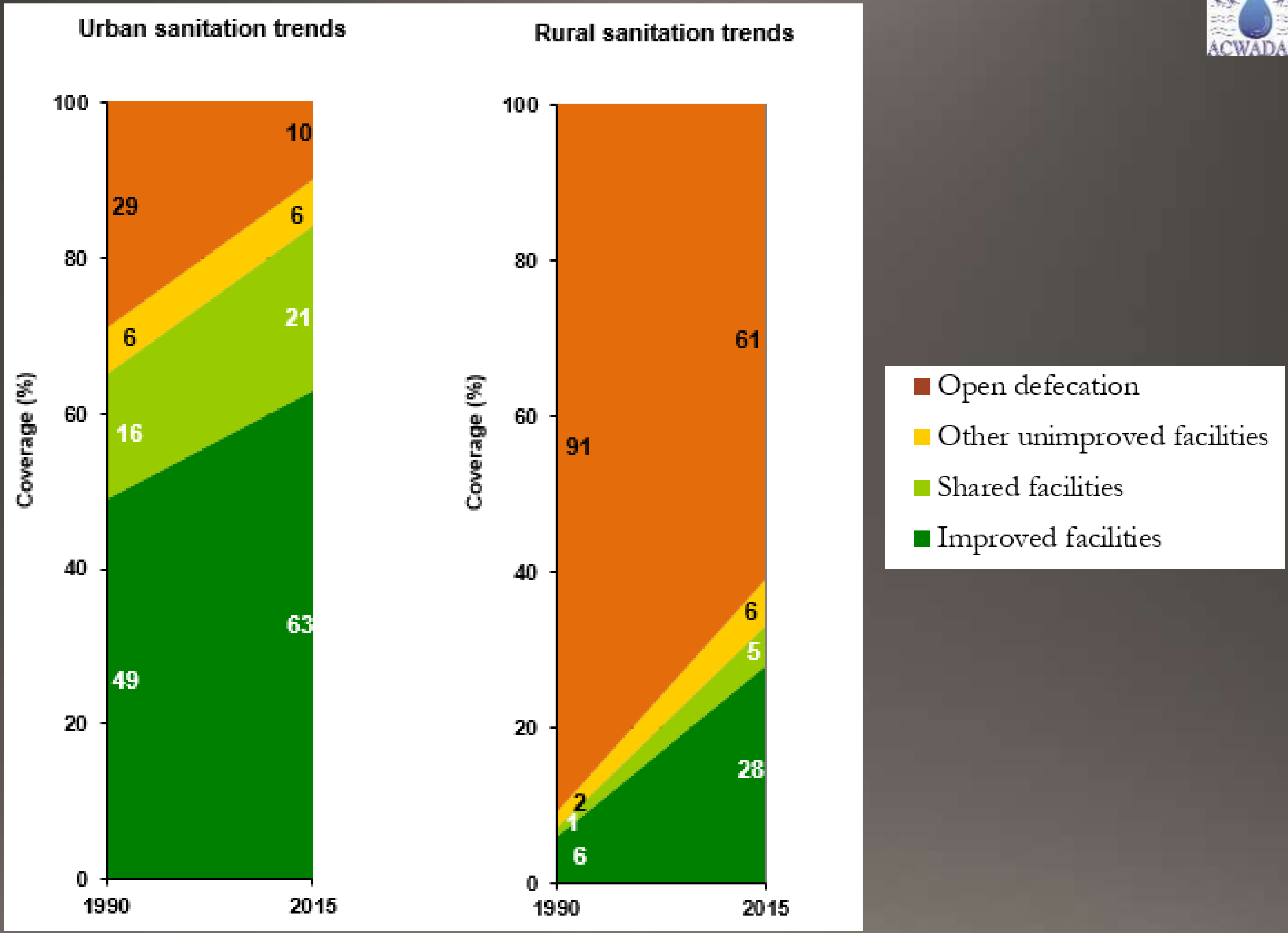
Viruses

Immune status

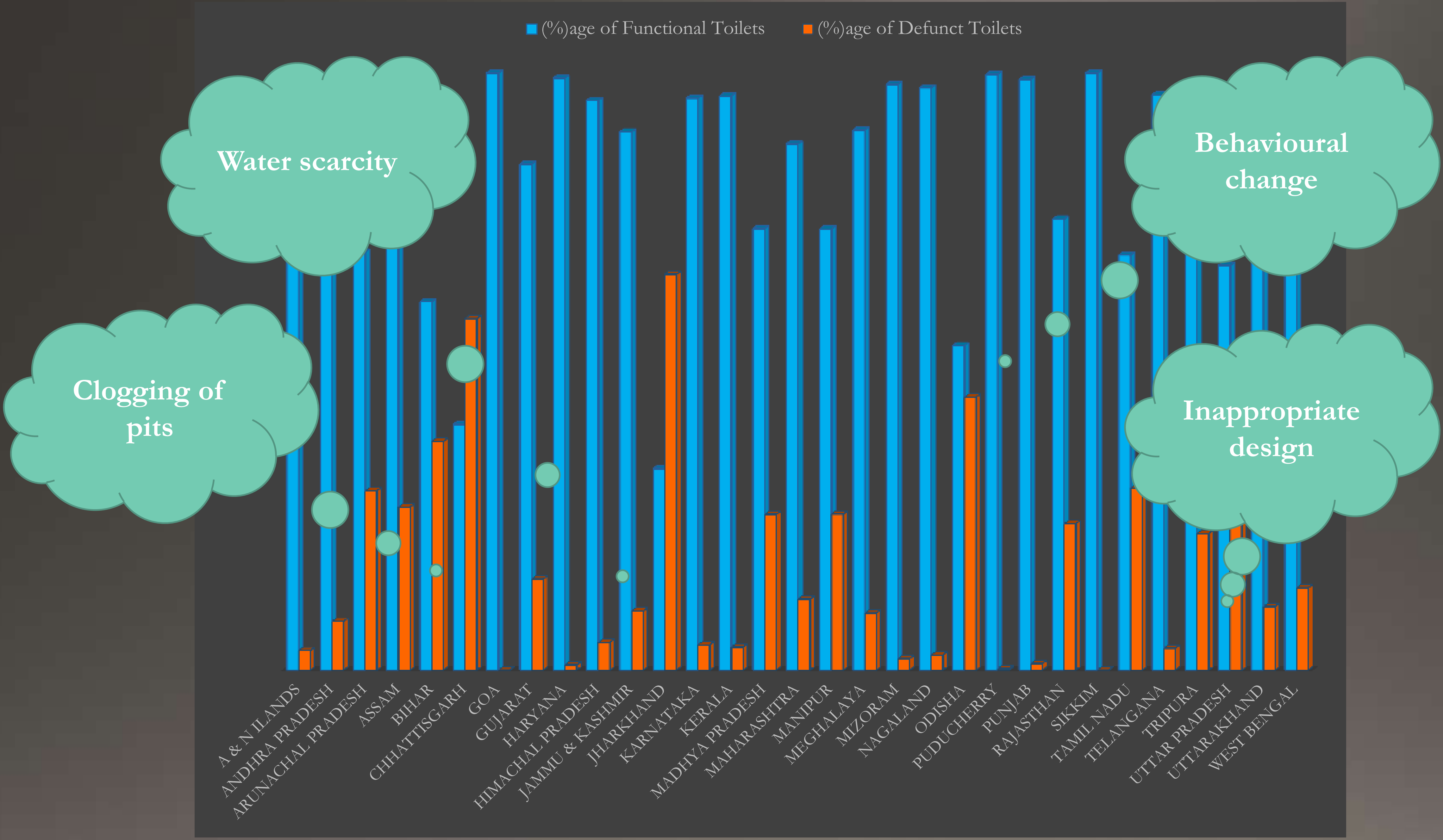
Nutritional status

Drinking water standard and sanitation

Sulphate, SO_4	
IS 10500-1991	Desirable : 200 mg/l, Permissible : 400 mg/l
Risks or effects	Bitter, medicinal taste, scaly deposits, corrosion, laxative effects, "rotten-egg" odor from hydrogen sulfide gas formation
Sources	Animal sewage, septic system, sewage By-product of coal mining, industrial waste Natural deposits or salt
Sulphate Treatment	Ion Exchange , Distillation , Reverse Osmosis



Source: WHO/UNICEF JMP: Estimates on use of water sources and sanitation facilities, updated June 2015

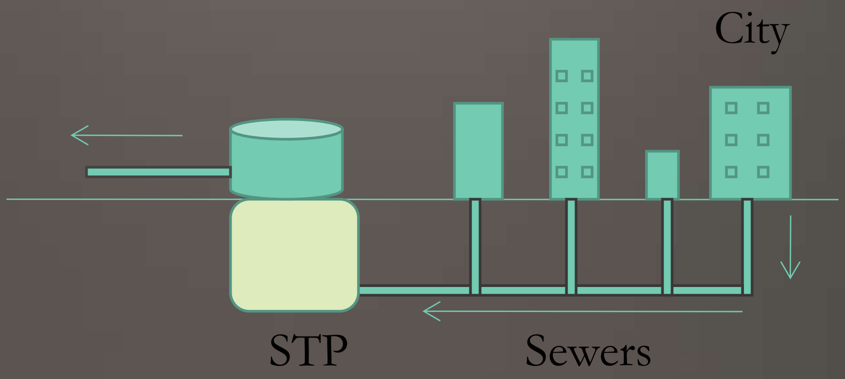


Source: Swach Bharat Mission, Guidelines

Types of sanitation

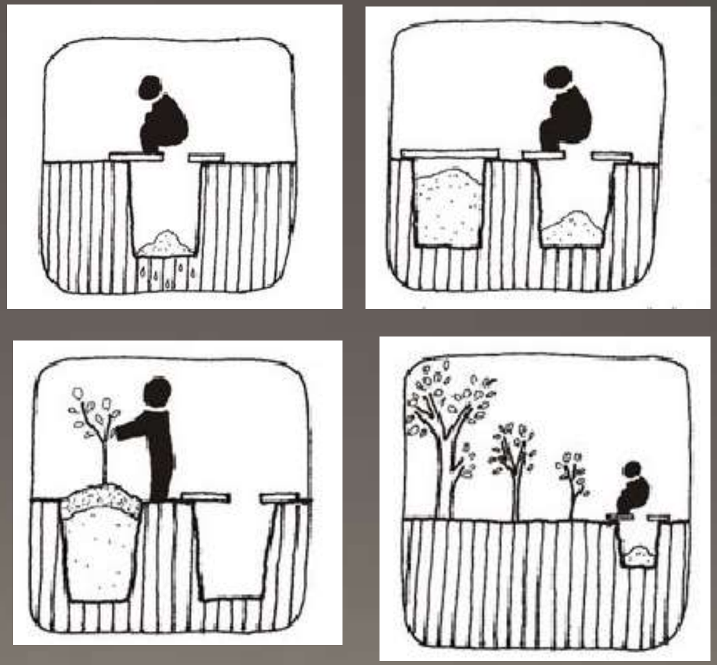
Off-site Sanitation

- Urban areas
- Sewer systems
- No household treatment
- Treatment plant



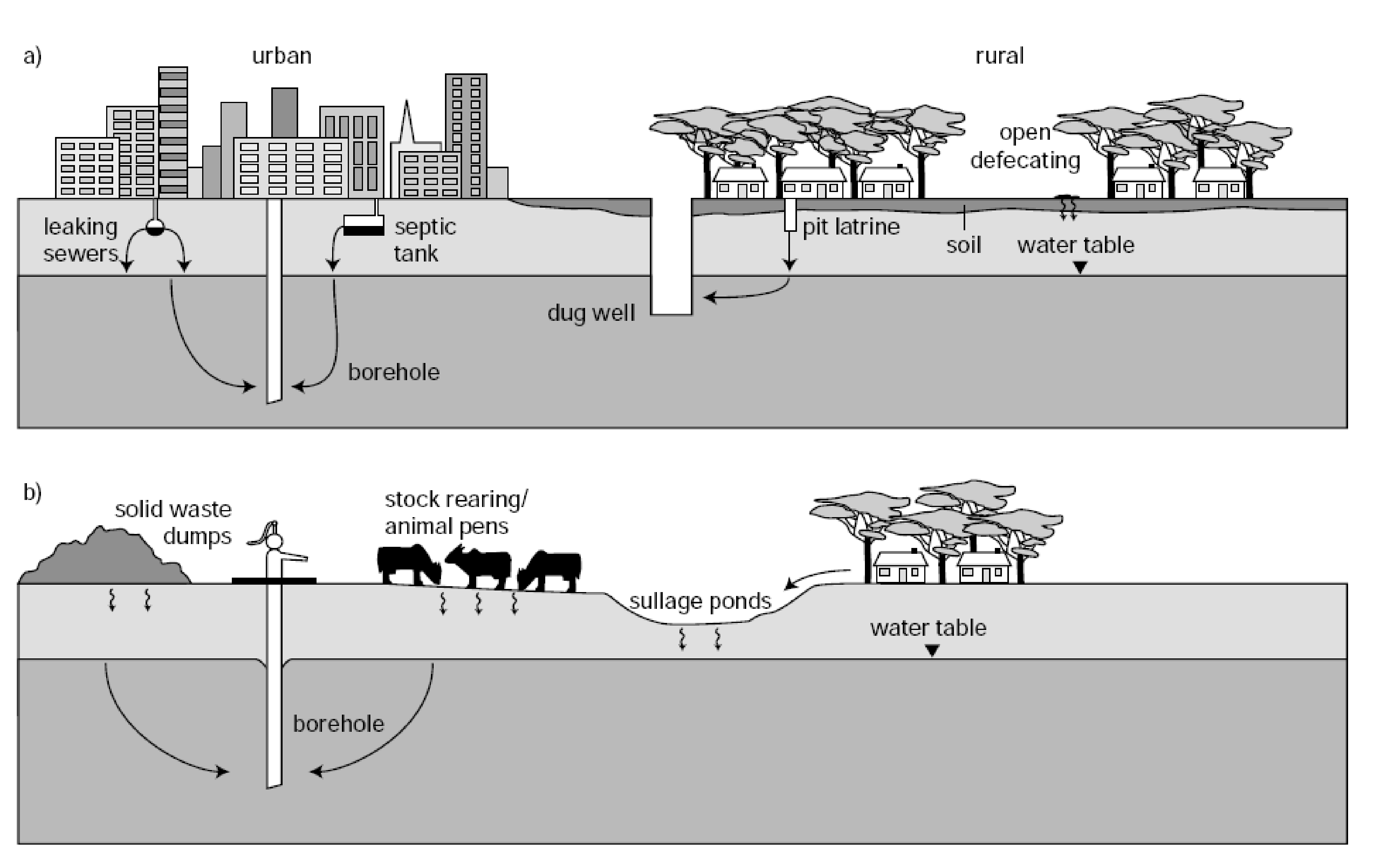
On-site Sanitation

- Rural areas
- Soak pit, Septic tank, Dry-box UDT
- Storage at disposal
- on-site decomposition
- Periodic emptying

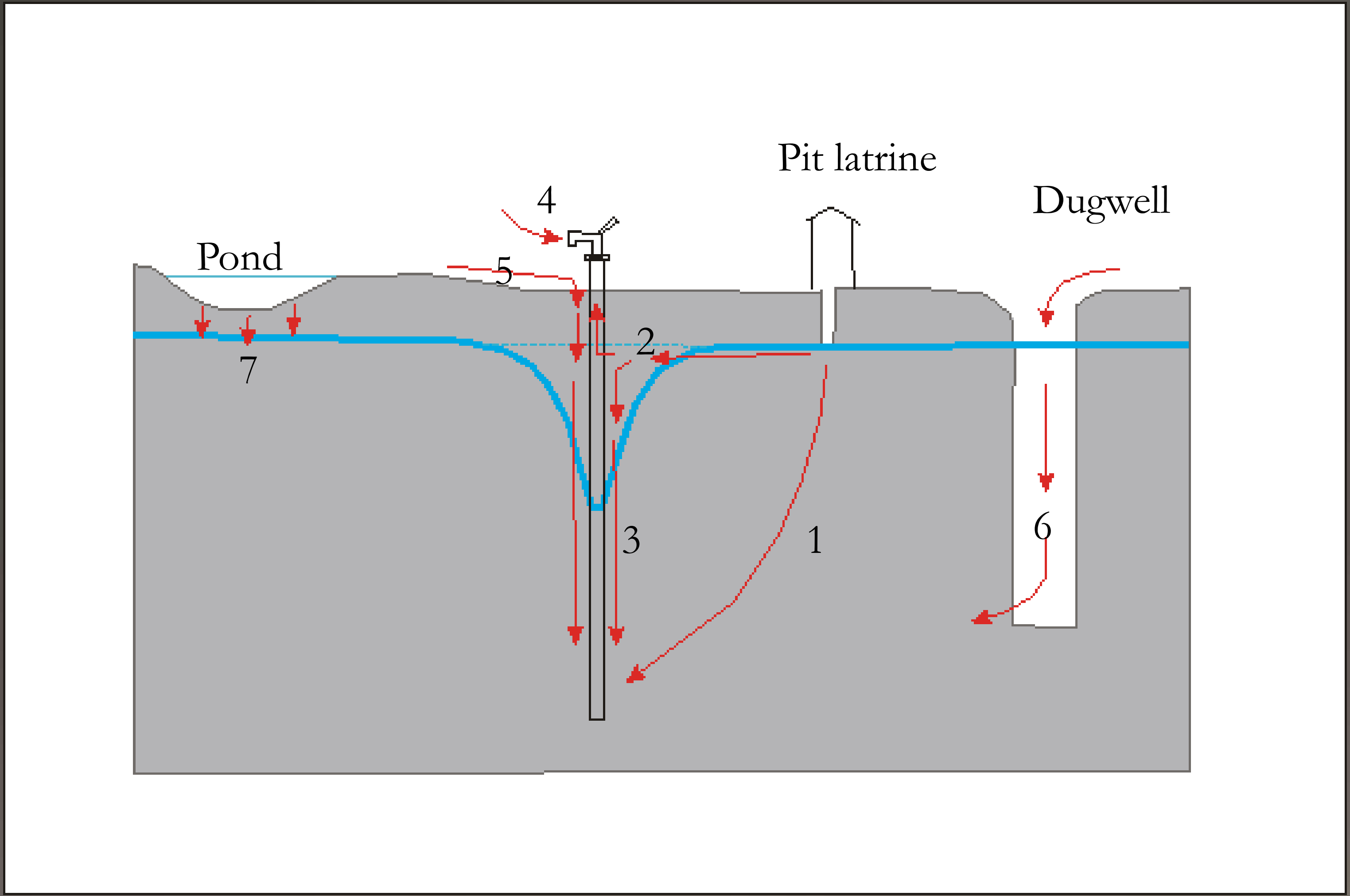


Soak pits

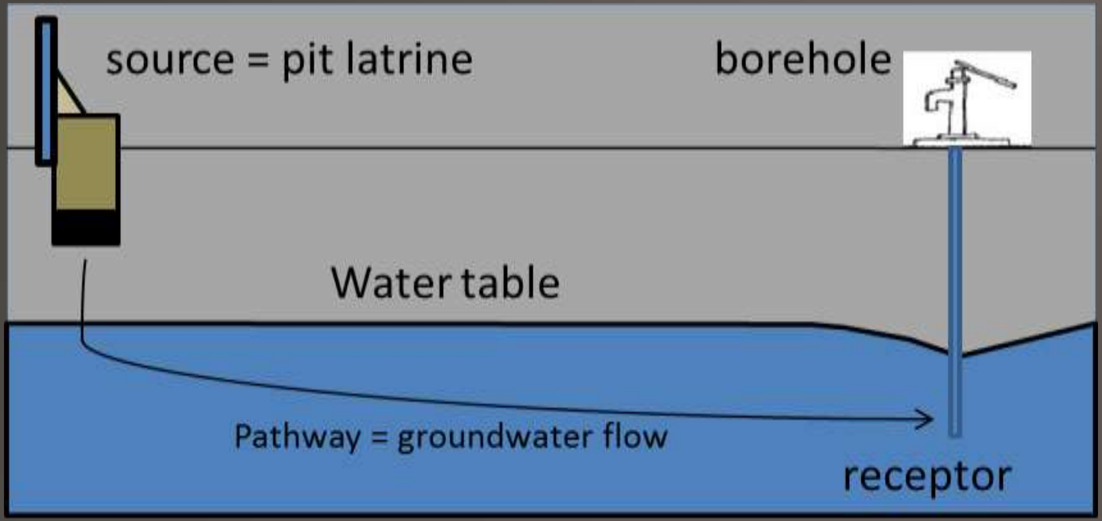
Sources of contamination

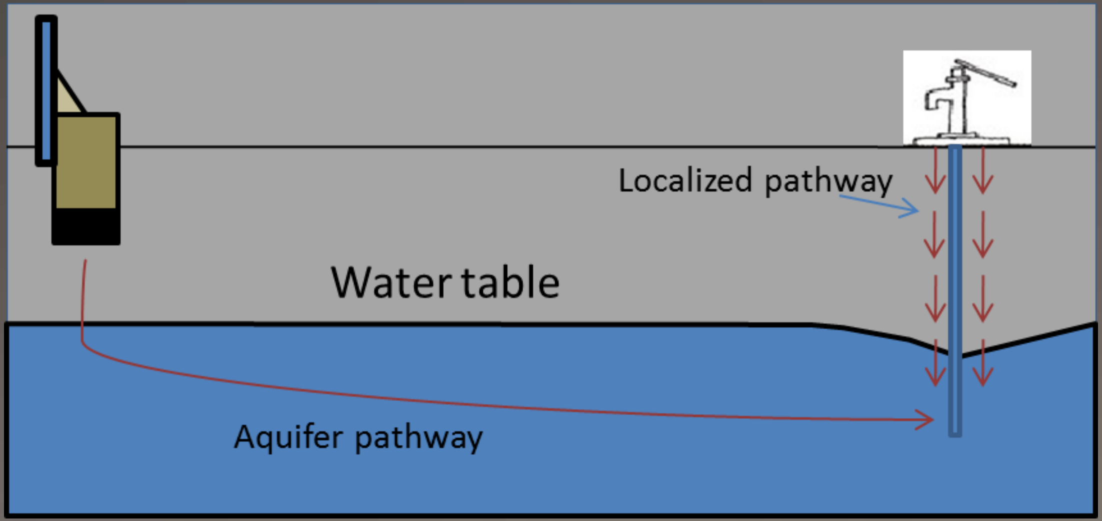


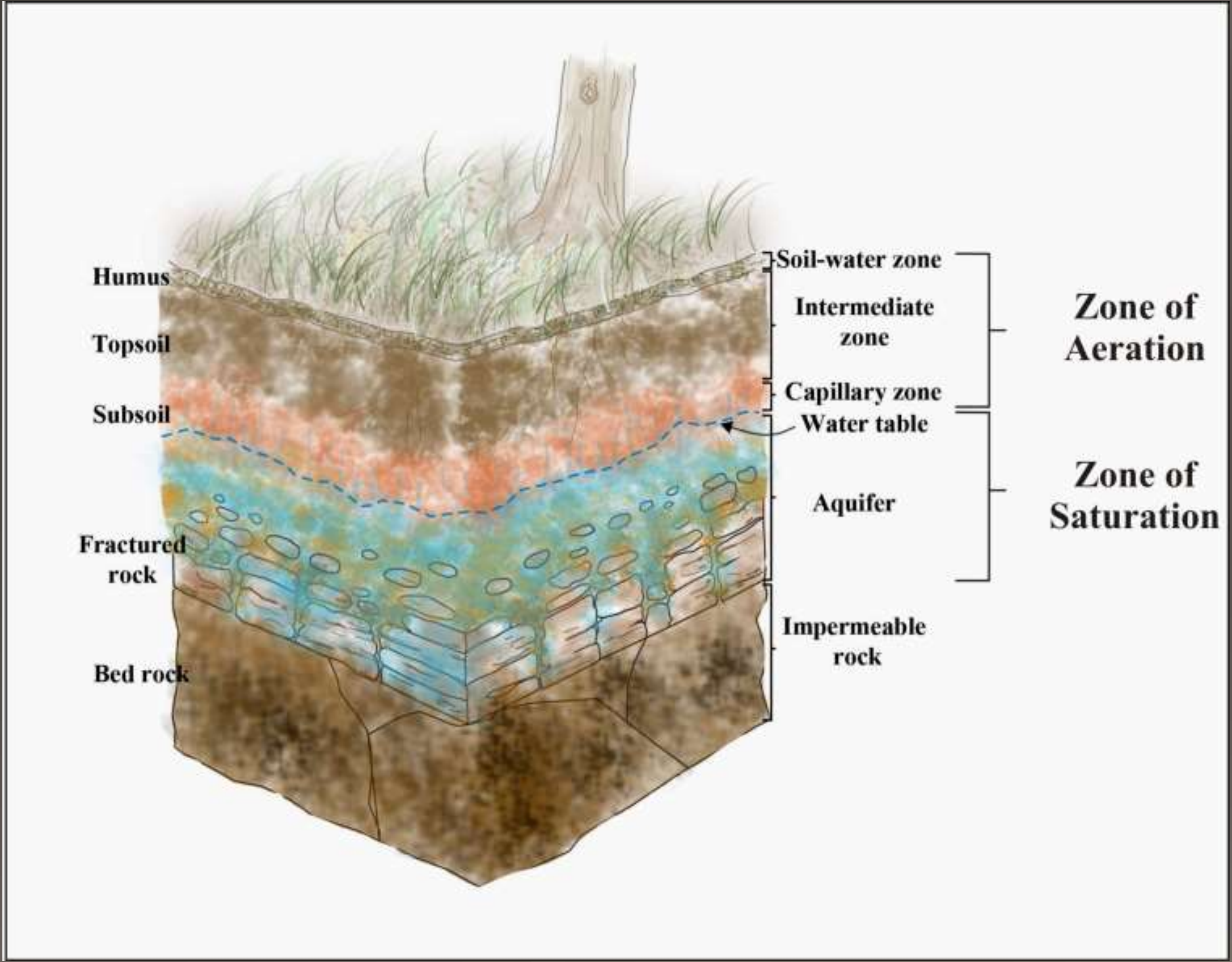
Pathways for contamination



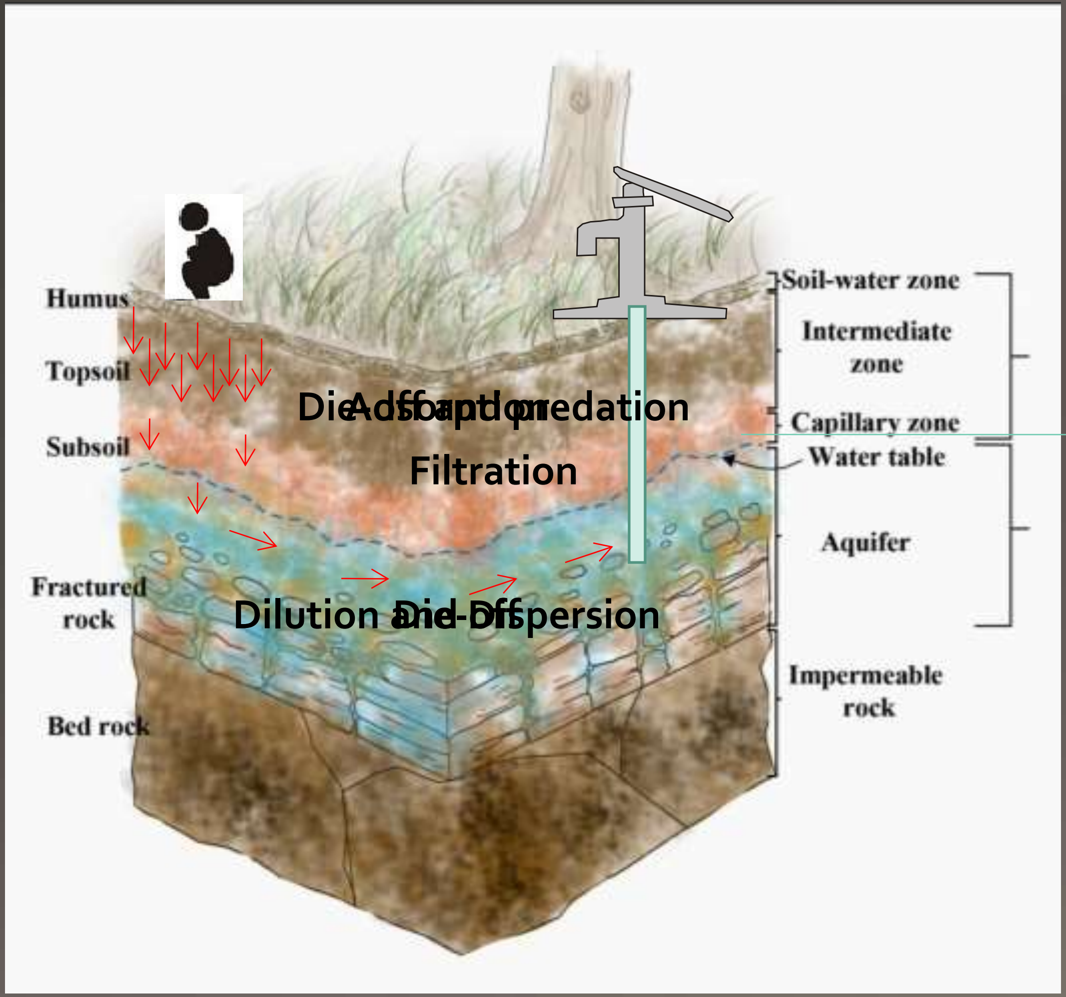
Risk: Source – Pathway - Receptor






Humus
Topsoil
Subsoil
Fractured rock
Bed rock
Soil-water zone
Intermediate zone
Capillary zone
Water table
Aquifer
Impermeable rock
Zone of Aeration
Zone of Saturation

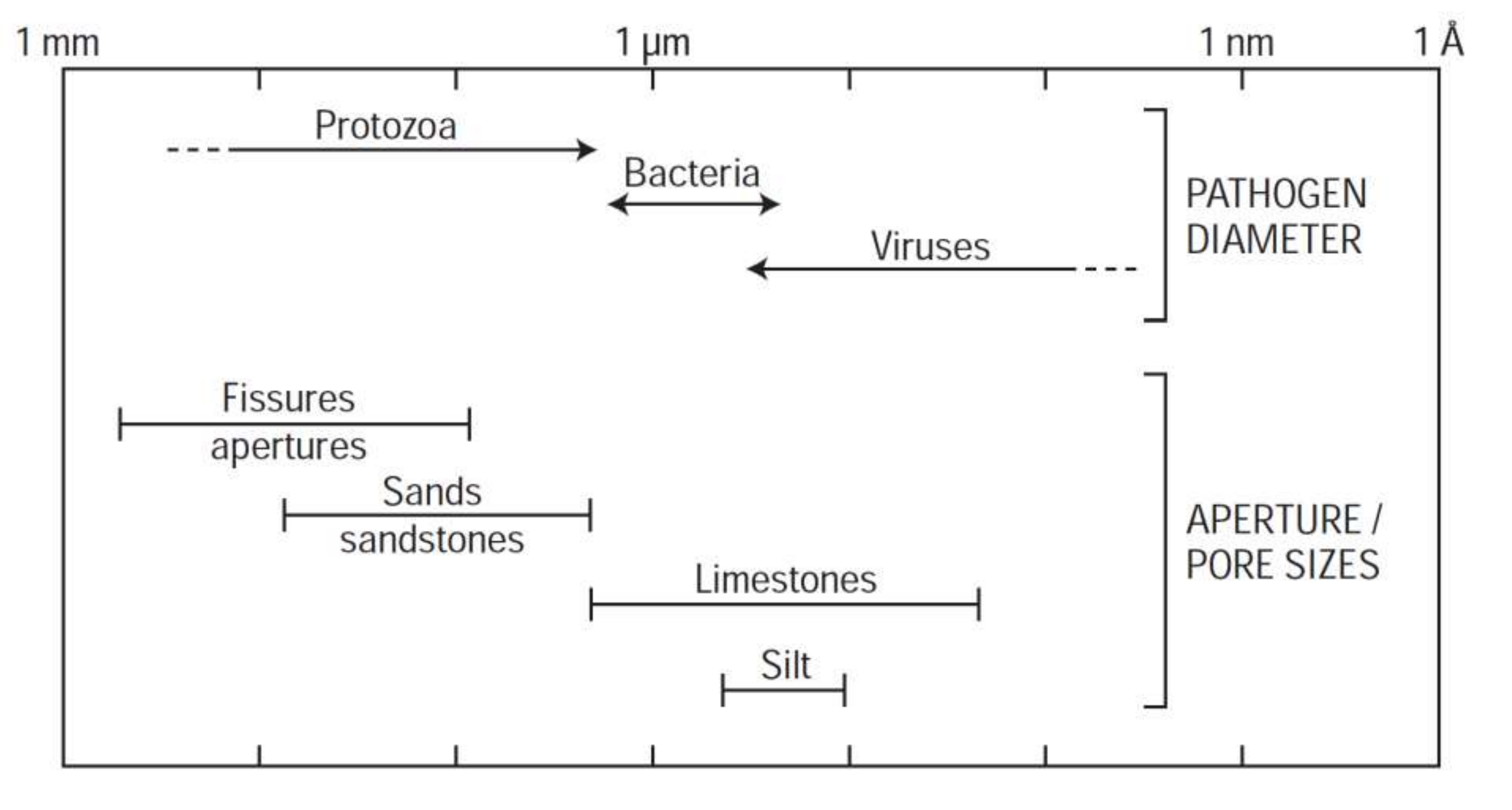
As water moves through the ground, natural processes reduce (or attenuate) the Concentration of many contaminants including harmful microorganisms.



Significance of the Unsaturated zone

Significance of the Saturated zone

Filtration

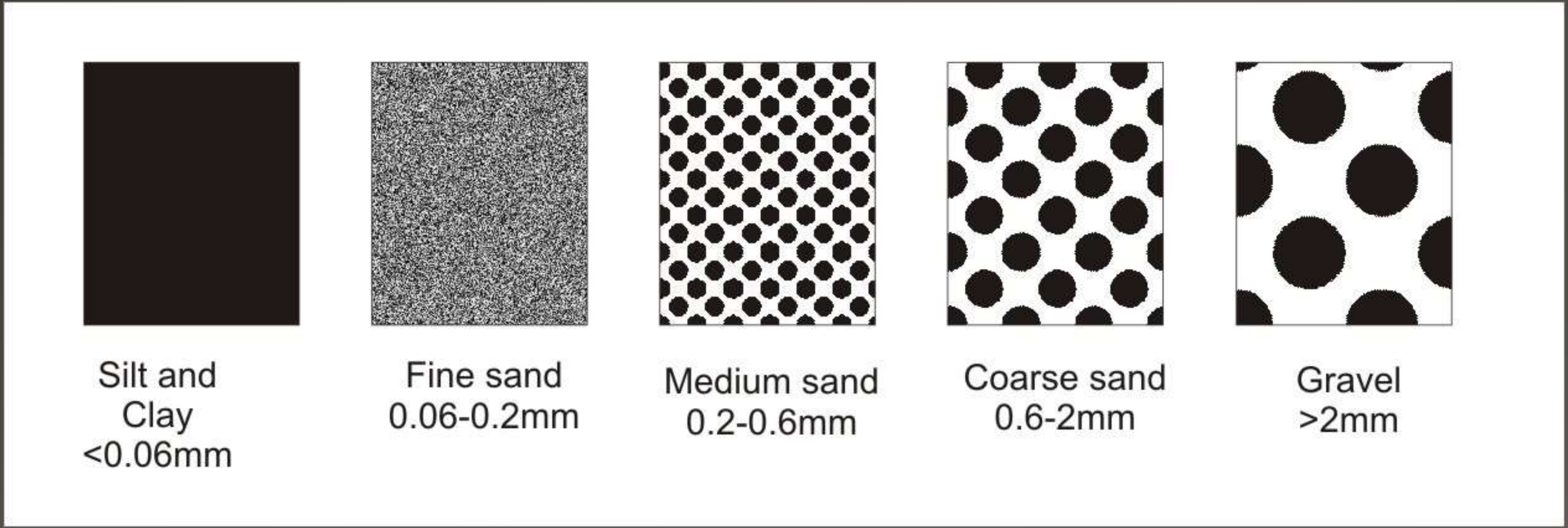

1 mm
1 µm
1 nm
1 Å
Protozoa
Bacteria
Viruses
PATHOGEN DIAMETER
Fissures apertures
Sands sandstones
Limestones
Silt
APERTURE / PORE SIZES

Adsorption

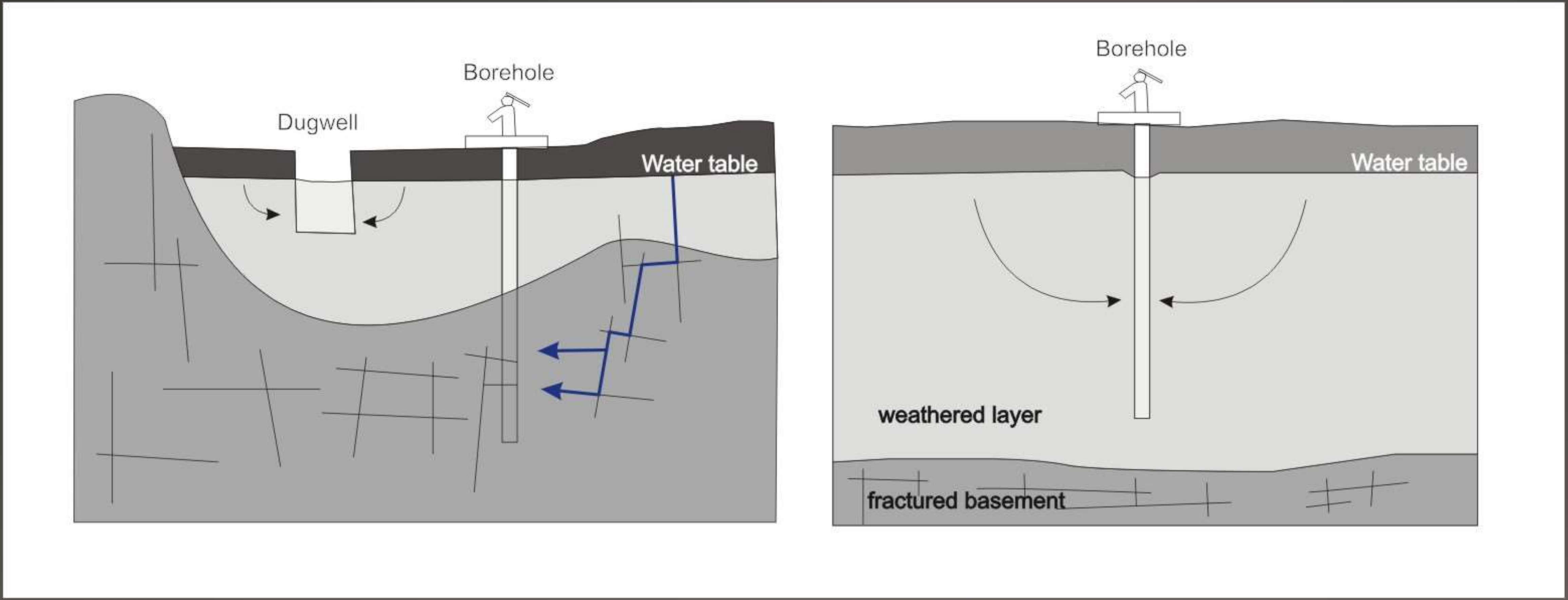
Factors influencing movement of bacteria and viruses through soil

Rainfall	Micro-organisms retained near the soil surface may be eluted after heavy rainfall because of the establishment of ionic gradients within the soil column
PH	Low pH favours virus adsorption; high pH results in elution of adsorbed viruses
Soil composition	Bacteria and viruses are readily absorbed to clays under appropriate conditions, and the higher the clay content of the soil, the greater the removal. Sandy loam soils and other soils containing organic matter are also favourable for removal
Hydraulic loading/flow rate	As the flow rate increases, micro-organisms penetrate deeper. The hydraulic loading is naturally increased during periods of groundwater recharge by infiltrating rainfall
Soluble organics	Soluble organic matter has been shown to compete with organisms for adsorption sites on the soil particles, resulting in decreasing adsorption or elution of already adsorbed viruses
Cations	Cations, especially divalent ones, can act to neutralise or reduce repulsive forces between negatively charged micro-organisms and oil particles, allowing adsorption to proceed

(after Gerba et al 1975)



Silt and Clay <0.06mm
Fine sand 0.06-0.2mm
Medium sand 0.2-0.6mm
Coarse sand 0.6-2mm
Gravel >2mm


Borehole
Dugwell
Water table
Borehole
Water table
weathered layer
fractured basement

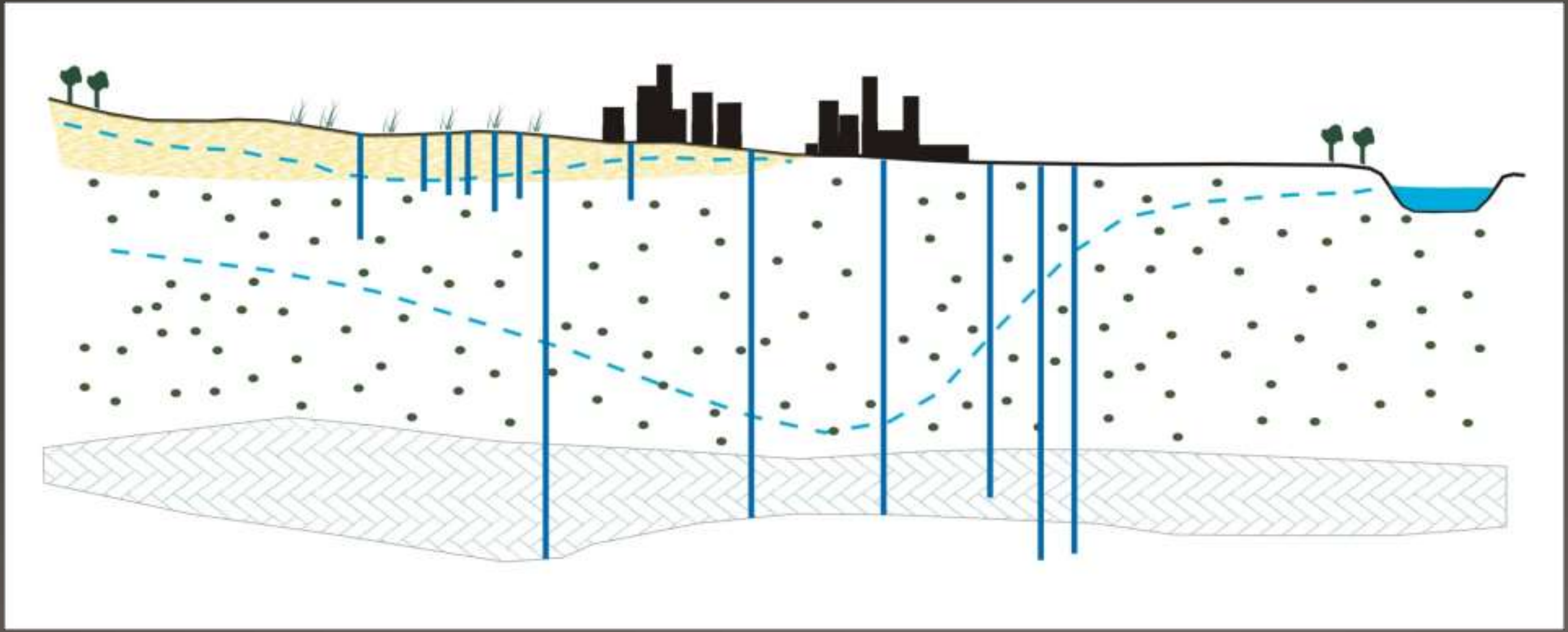
Hydrogeological environment		natural travel time to saturated zone	attenuation potential	pollution vulnerability
Thick sediments associated with rivers and coastal regions	shallow layers	weeks-months	low-high	high
	deep layers	years-decades	high	low
Mountain valley sediments	shallow layers	months-years	low-high	low-high
	deep layers	years-decades	low-high	low-high
Minor sediments associated with rivers		days-weeks	low-high	extreme
Windblown deposits	shallow layers	weeks-months	low-high	high
	deep layers	years-decades	high	low
Consolidated sedimentary aquifers	sandstones	months-years	low-high	low-high
	karstic limestones	days-weeks	low	extreme
Weathered basement	thick weathered layer *(>20 m)*	weeks-months	high	low
	thin weathered layer *(<20 m)*	days-weeks	low-high	high

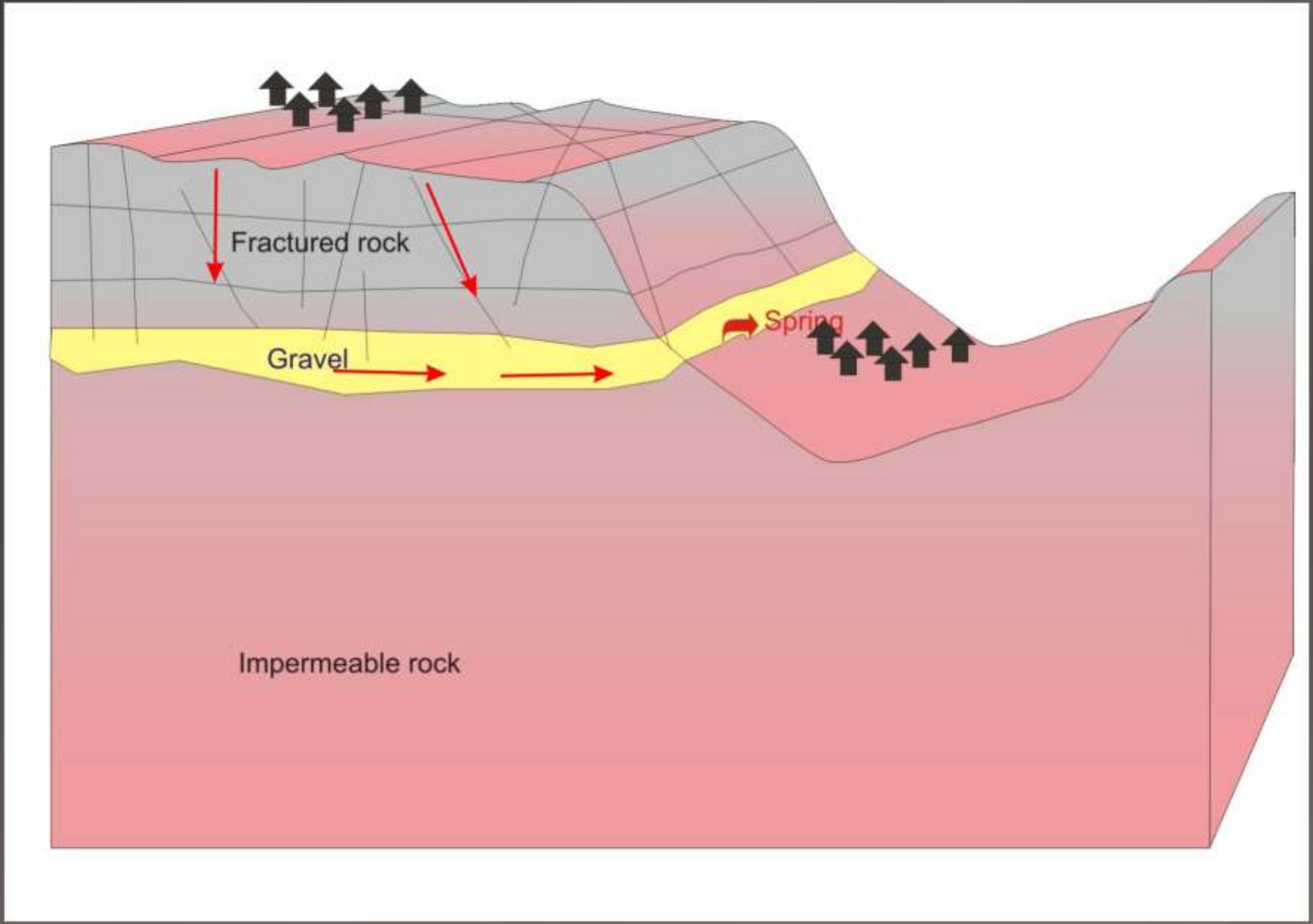
Rock types	Typical porosity	Typical Kh:Kv ratio#	Range of likely permeability (m/d)	Feasibility of using horizontal separation	Lateral separation to reduce pathogen arrival at water supply to low risk
Silt	0.1–0.2	10	0.01–0.1	Yes	up to several metres*
Fine silty sand	0.1–0.2	10	0.1–10	Yes, should be generally acceptable*	up to several metres*
Weathered basement (not fractured)	0.05–0.2	1-10	0.01–10	Yes	up to several metres*
Medium sand	0.2–0.3	1	10–100	uncertain, will need site specific testing and monitoring	Tens–hundreds of metres
Gravel	0.2–0.3	1	100–1000	not feasible	up to hundreds of metres
Fractured rocks	0.01	1	difficult to generalise, velocities of tens or hundreds of m/d possible	not feasible	up to hundreds of metres

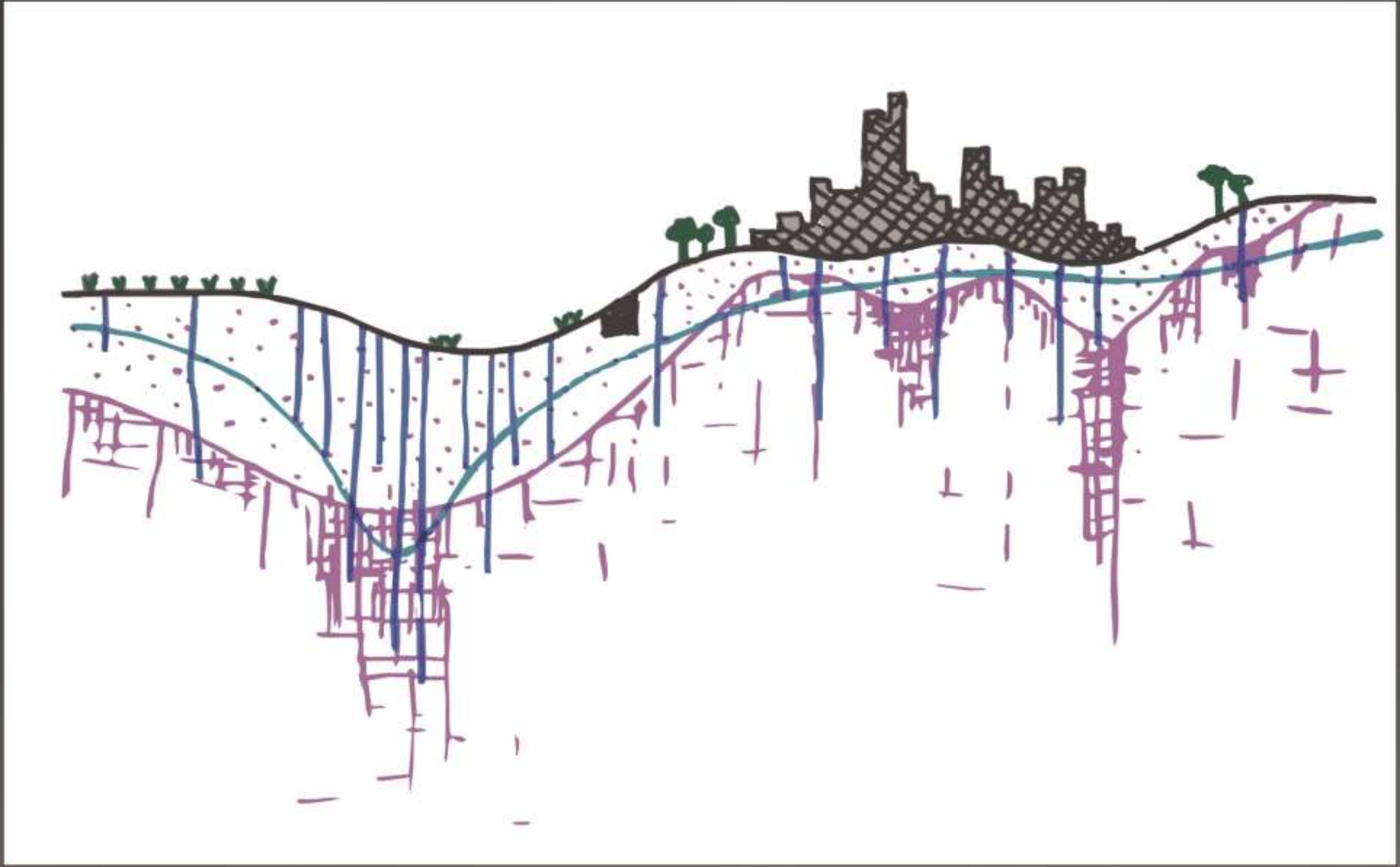
this is the ratio of horizontal permeability and vertical permeability – greater in fine-grained sedimentary rocks

* need to select a minimum separation to avoid localised contamination (see Section 4.4)

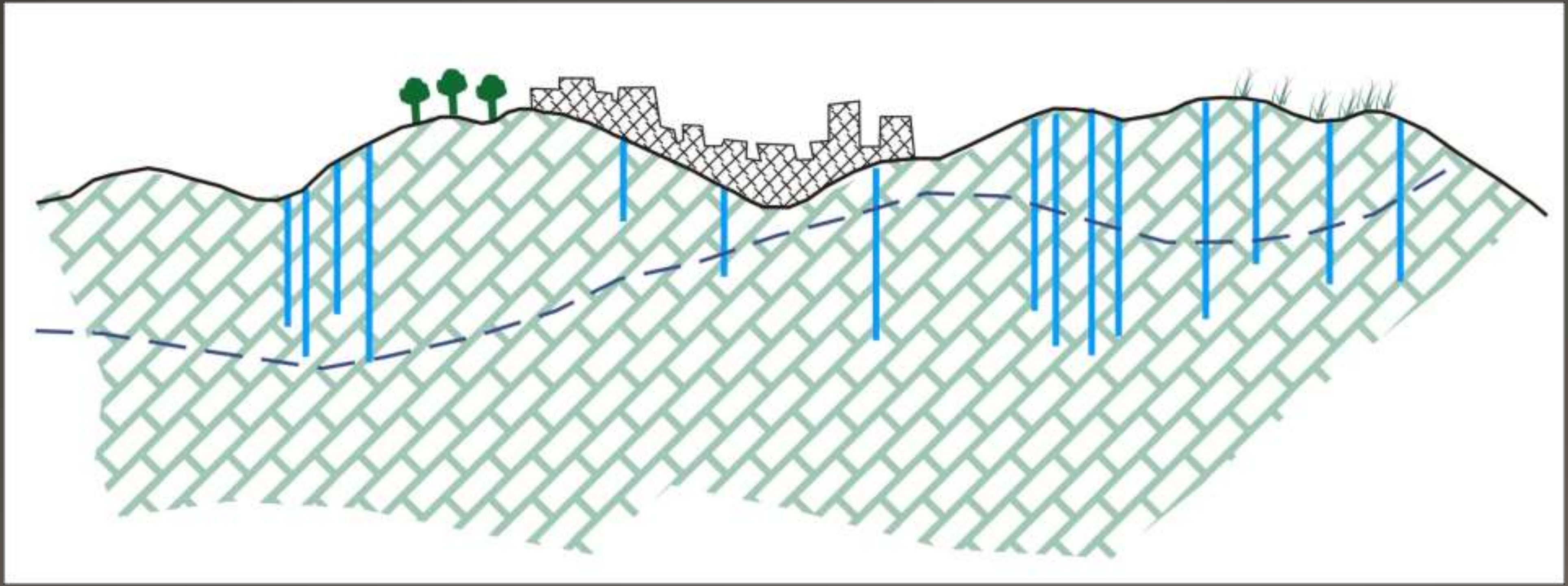
Alluvium



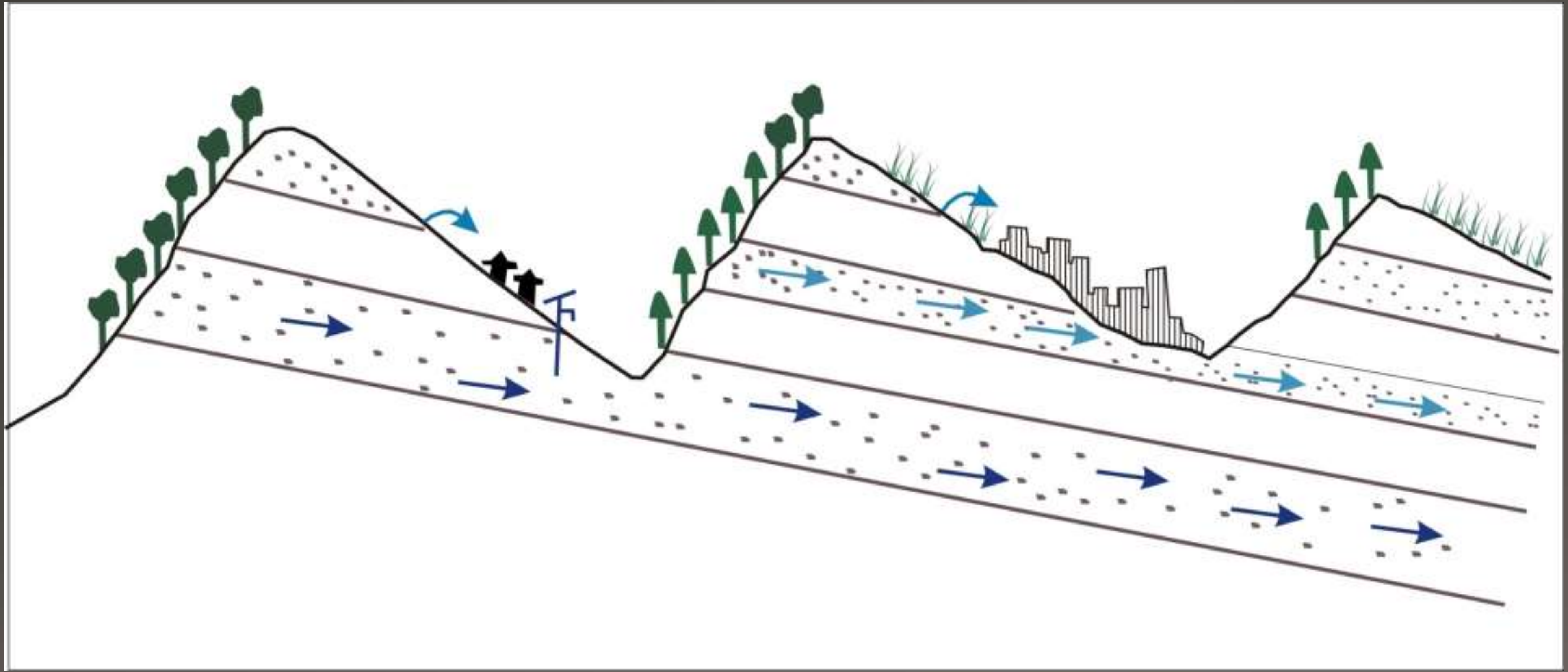

Fractured rock
Gravel
Spring
Impermeable rock



Karstic



Himalayas



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