- Studio avanzato dei principali **processi geochimici** dell'ambiente superficiale ed analisi dei fenomeni di perturbazione dei cicli naturali degli elementi a causa dell'impatto antropico.

- Acquisizione di competenze per un corretto **trattamento dei dati geochimici**, per la loro validazione dal punto di vista analitico e per la loro visualizzazione grafica e numerica. Introduzione all'uso del software open source R.

- Impostazione di **modelli concettuali** al fine di descrivere in modo competo i fenomeni naturali e antropici ed effettuare una loro analisi critica. Il ruolo della modellizzazione orientata su base termodinamica.

- Valutazione del comportamento degli elementi chimici in vari contesti naturali ed antropici, analisi dei cicli geochimici e bio-geochimici, metodi per l'identificazione dei **valori di background/baseline**.

- Analisi di casi studio. Analisi di reports internazionali.

The situation posed for example by the changes in the natural biogeochemical cycles of nitrogen and phosphorous has produced an attempt to define a planetary boundary for their flows, which could be considered as a safety threshold.

nature Vol 461|24 September 2009

FEATURE

A safe operating space for humanity

Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue **Johan Rockström** and colleagues.

SUMMARY

- New approach proposed for defining preconditions for human development
- Crossing certain biophysical thresholds could have disastrous consequences for humanity
- Three of nine interlinked planetary boundaries have already been overstepped

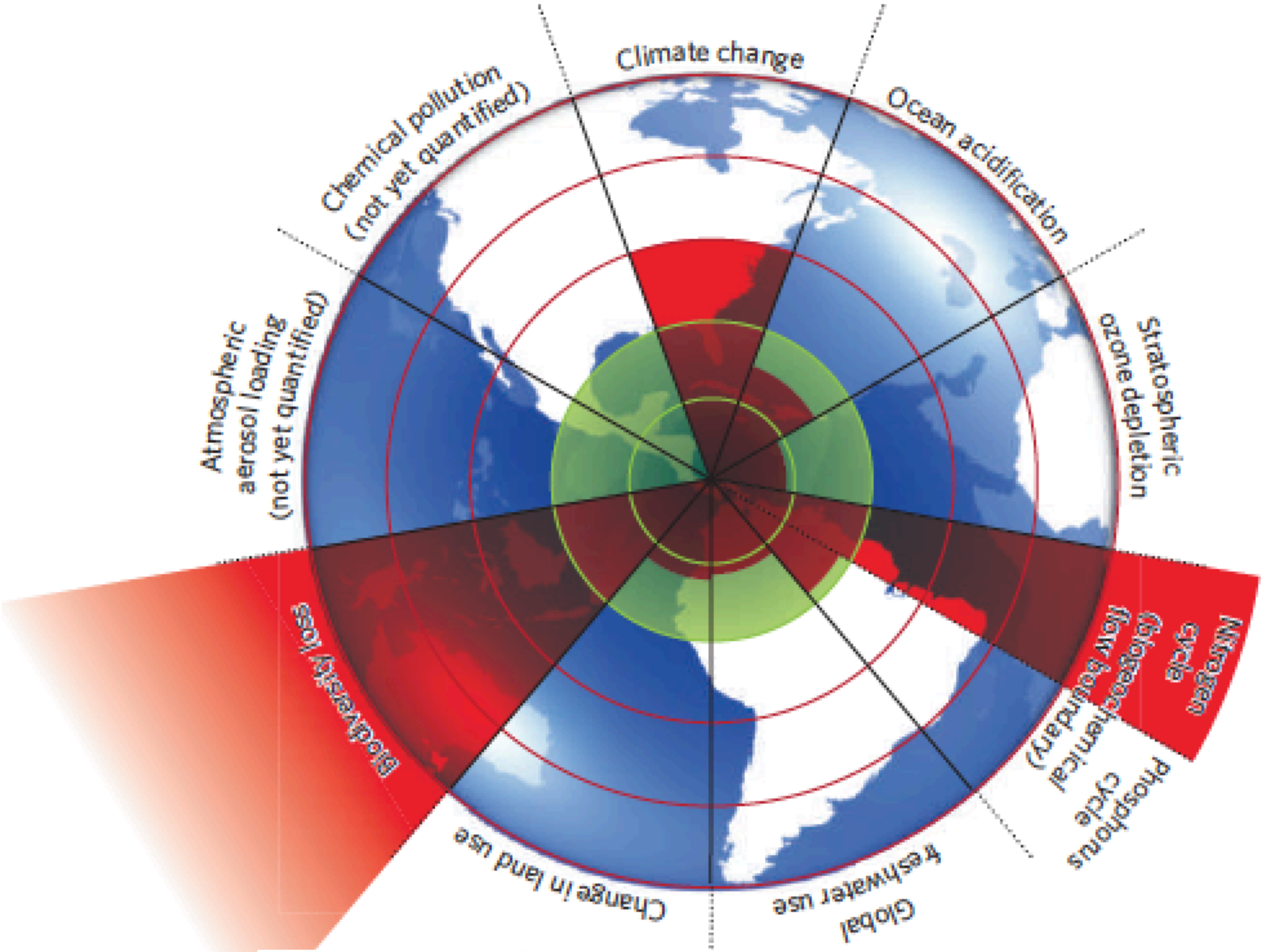


Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

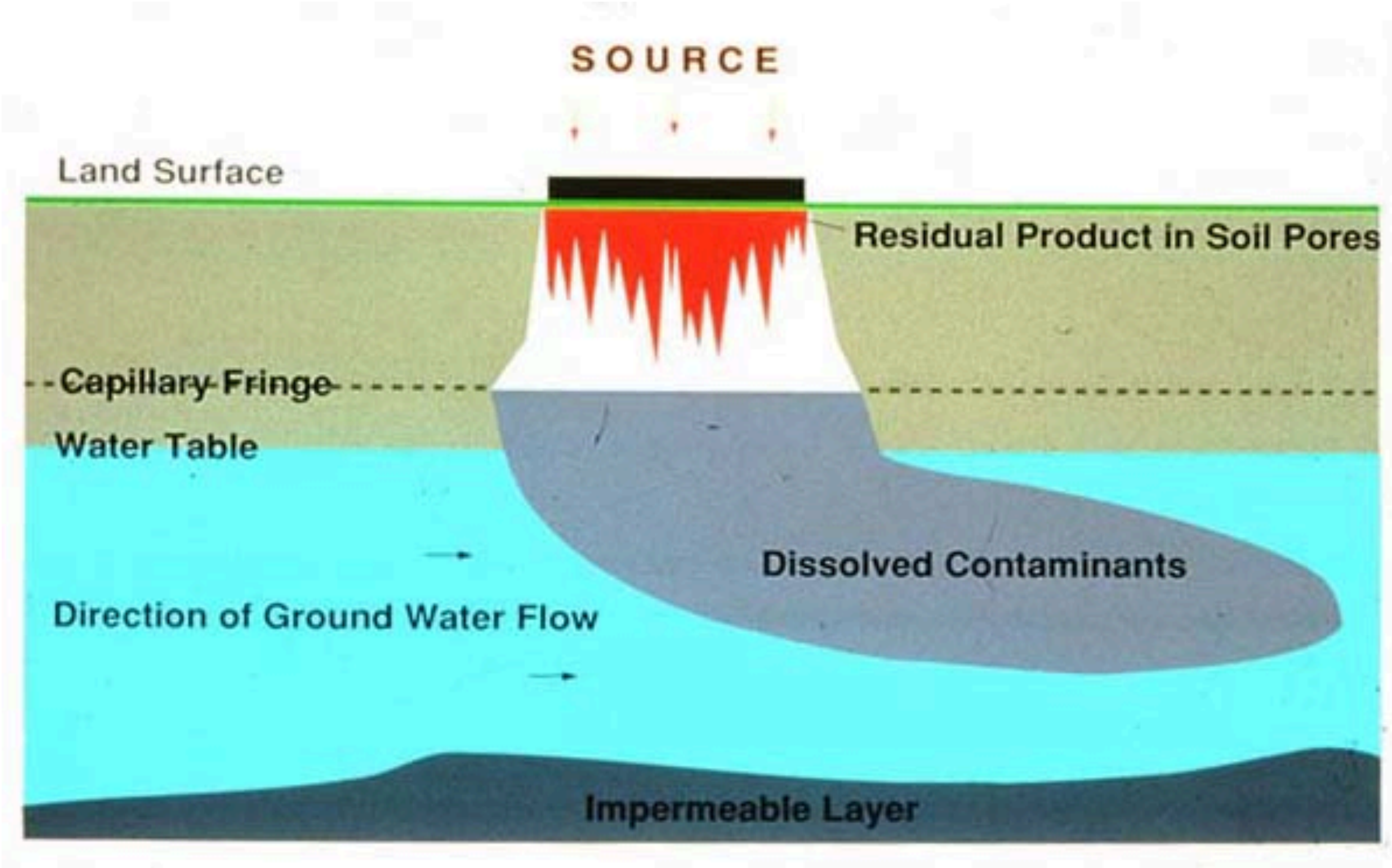
Modern agriculture is a **major cause** of environmental pollution, including large-scale nitrogen- and phosphorus-induced environmental change.

At the planetary scale, the additional amounts of nitrogen and phosphorus activated by humans are now so large that they **significantly perturb** the ***global cycles*** of these two important elements.

PLANETARY BOUNDARIES

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1–1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	-1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis		To be determined	
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in the global environment, or the effects on ecosystem and functioning of Earth system thereof		To be determined	

Millions of people in the developing world rely heavily on groundwater, mostly through shallow dug wells. These can easily **become polluted**, primarily because of human activities. Such activities can be broadly categorized into four groups: ***municipal***, ***industrial, agricultural***, and ***individual sources***.



Contamination of drinking-water by arsenic in Bangladesh: a public health emergency

Allan H. Smith,[1] Elena O. Lingas,[2] & Mahfuzar Rahman

Table 1. **Percentage of groundwaters surveyed in 1998 by the British Geological Survey with arsenic levels over 50 µg/l**

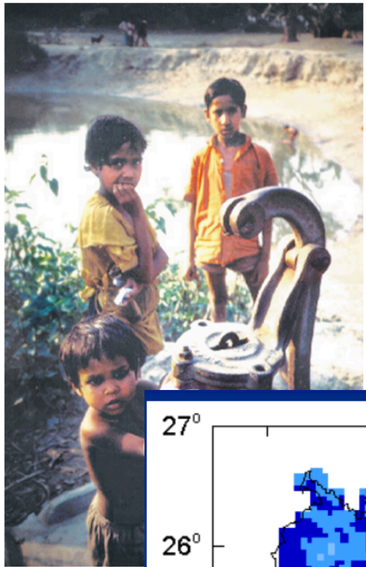
District	% of groundwaters surveyed	District	% of groundwaters surveyed
Bagerhat	66	Madaripur	93
Barisal	63	Magura	19
Brahmanbaria	38	Manikganj	15
Chandpur	96	Meherpur	60
Chittagong	20	Moulvibazar	12
Chuadanga	44	Munshiganj	83
Comilla	65	Narail	43
Cox's Bazar	3	Narayanganj	24
Dhaka	37	Nawabganj	4
Faridpur	66	Noakhali	75
Feni	39	Pabna	17
Gopalganj	94	Pirojpur	24
Jessore	51	Rajbari	24
Jhalakati	14	Rajshashi	6
Jhenaidah	26	Satkhira	73
Khulna	32	Shariatpur	80
Kushtia	28	Sylhet	19
Lakshmipur	68		

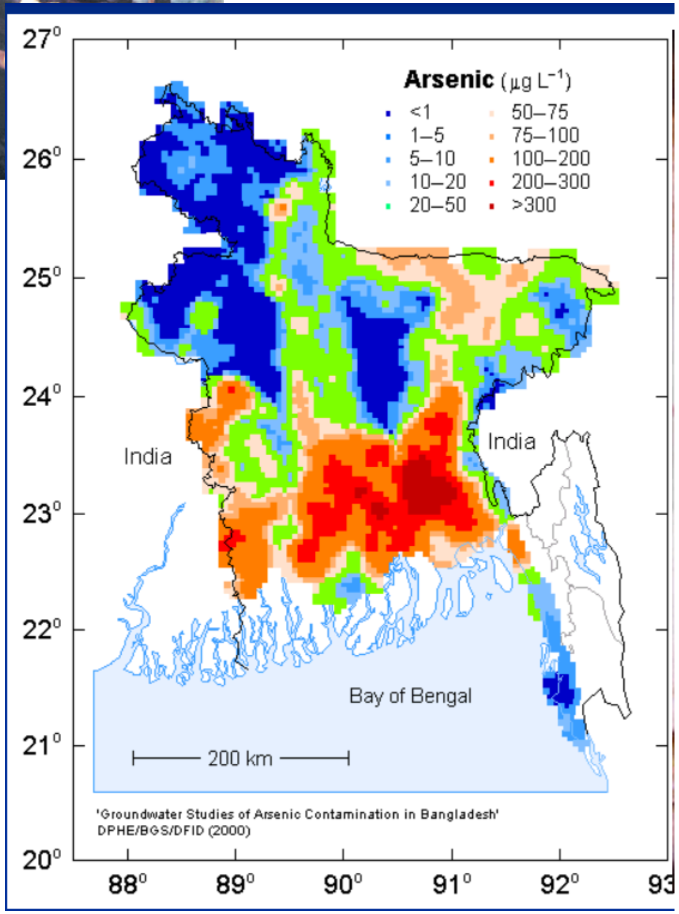
Bulletin of the World Health Organization, 2000, **78** (9)

Skin lesions due to arsenic poisoning

WHO 00229

Fig. 2. **Children near a tube-well disconnected due to contamination of water with arsenic**



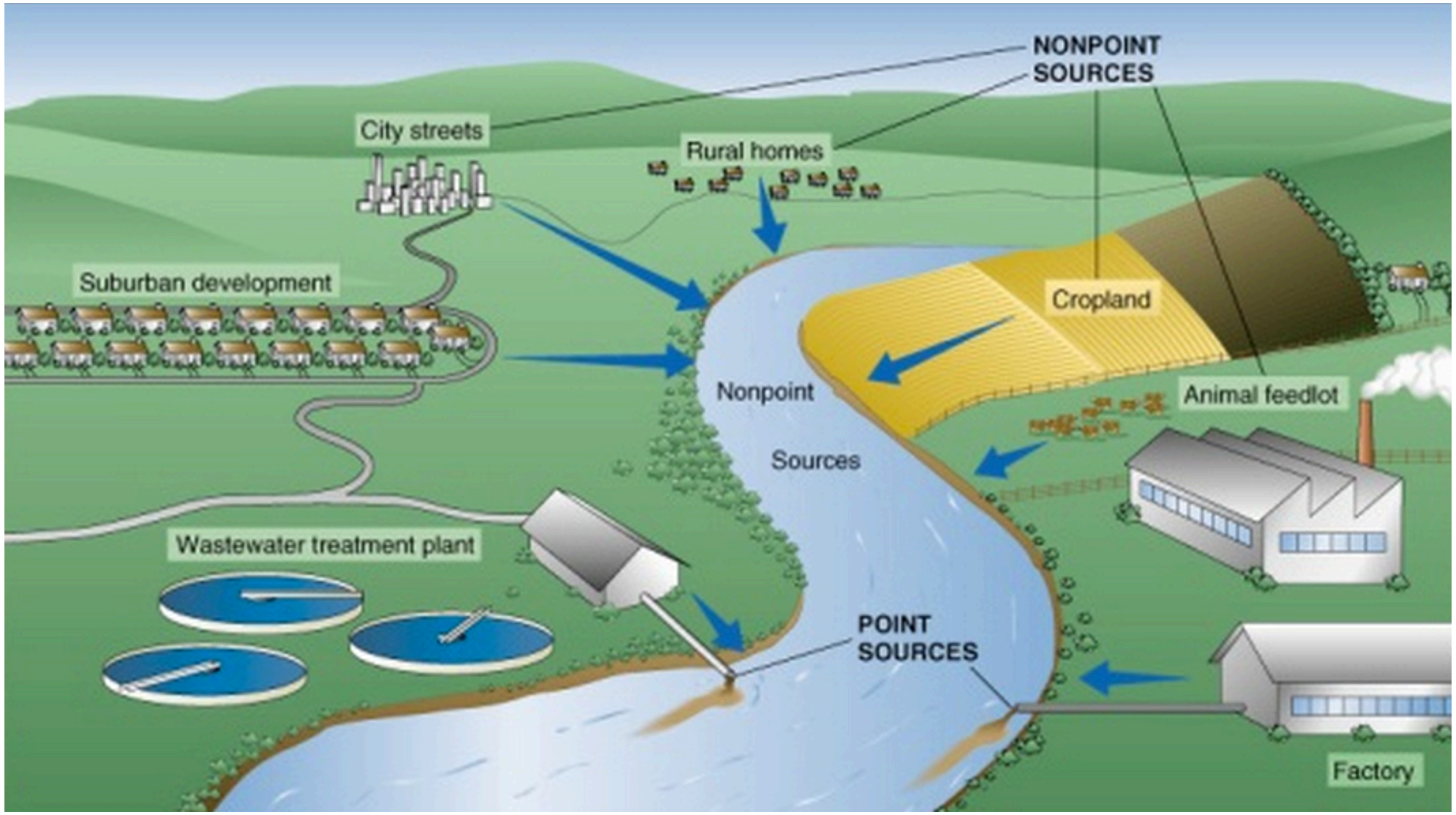


Box 1. **Magnitude of arsenic poisoning in Bangladesh**

Population of Bangladesh:	125 million
Total population in regions where some wells are known to be contaminated:	35–77 million
Maximum concentration of arsenic permitted in drinking-water according to WHO recommendations:	10 µg/l
Maximum concentration allowed in Bangladesh:	50 µg/l (similar to many countries worldwide)
Number of tube-wells sampled by the British Geological Survey (1998):	2022
– Proportion of wells with arsenic concentrations >50 µg/l:	35%
– Proportion of wells with arsenic concentrations >300 µg/l:	8.4%

Groundwater pollution differs from surface water contamination in several important respects. Among these, it does not typically derive from a single outlet. It can affect people through wells dug in a contaminated aquifer, as it can flow into streams or lakes.

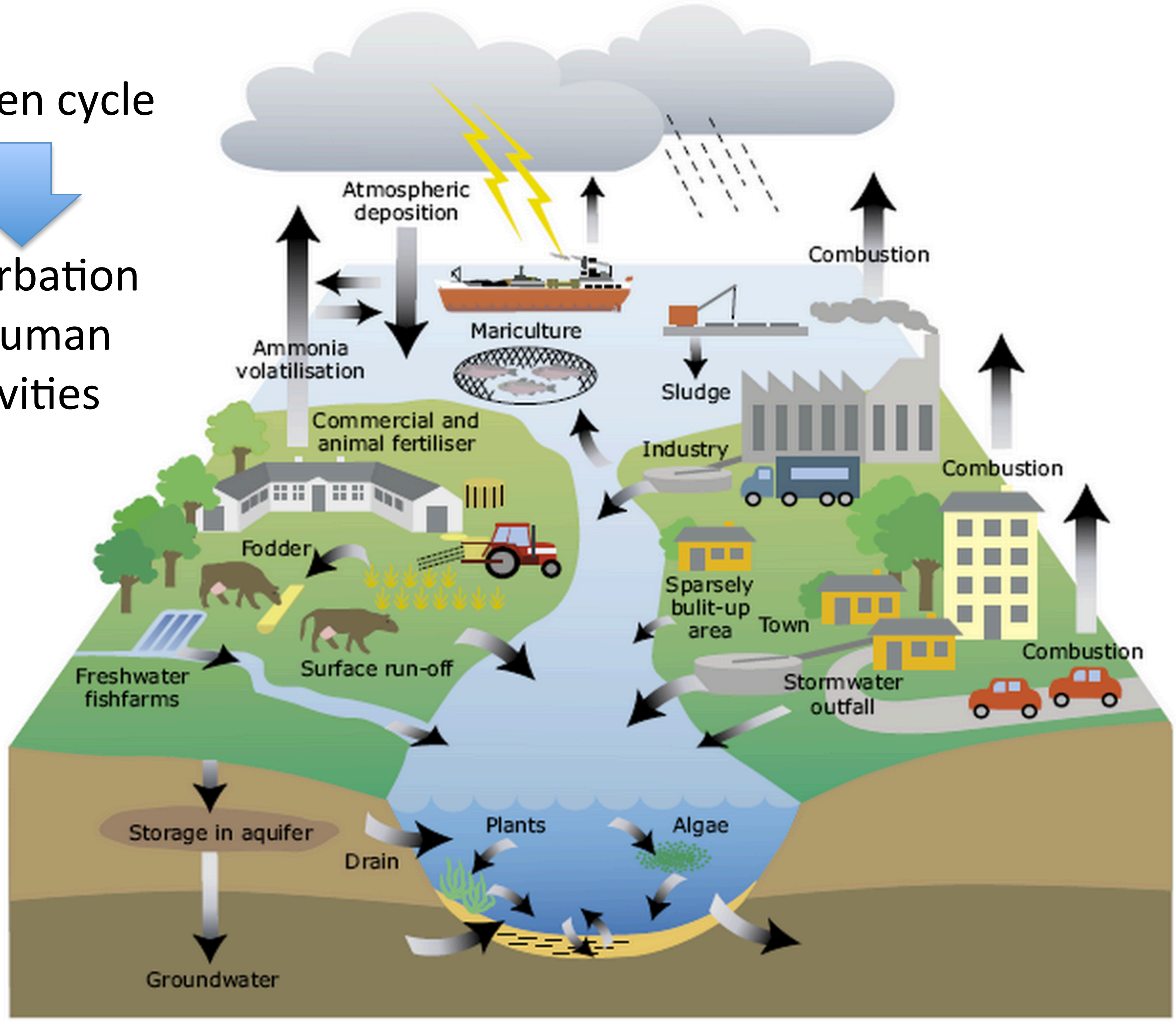
Groundwater pollution also occurs on **a different timescale** from surface water contamination. Flow rates vary widely and can be as slow as 2 miles a year. Because of this, nonpoint source pollution can take years or even decades to appear in wells and just as long or even longer to dissipate or be converted.



These distinctions depend on topography, hydrology and the sources of groundwater recharge and have implications for limiting as well as remediating contamination.

Nitrogen cycle

perturbation by human activities



Modern agricultural practice is a major cause of environmental pollution, significantly perturbing biogeochemical cycles on the planetary scale (Herivaux et al., 2013).

Gillings and Hagan-Lawson *Earth Perspectives* 2014, **1**:2
http://www.earth-perspectives.com/1/1/2

Earth Perspectives
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REVIEW **Open Access**

The cost of living in the Anthropocene

Michael R Gillings[1*] and Elizabeth L Hagan-Lawson[2]

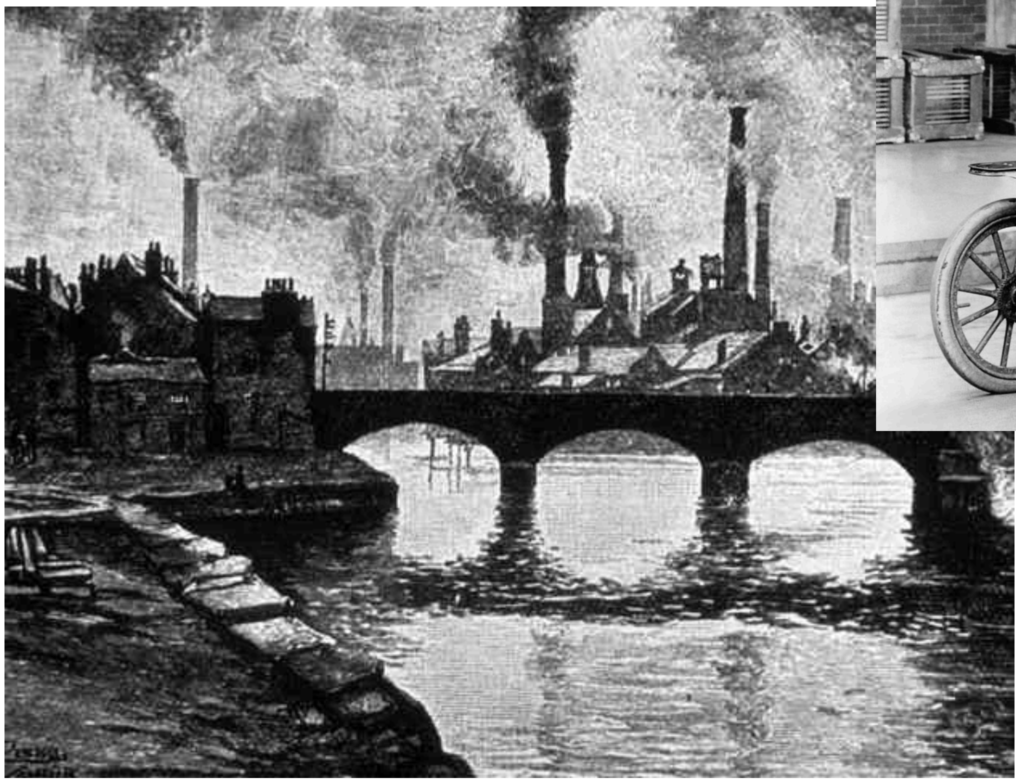
The idea that human activities have the power to affect Earth' s systems was recognized in the late 1800s by the geologist Antonio Stoppani, who coined the term ' Anthropozoic Era' to highlight this conclusion (Crutzen 2002).

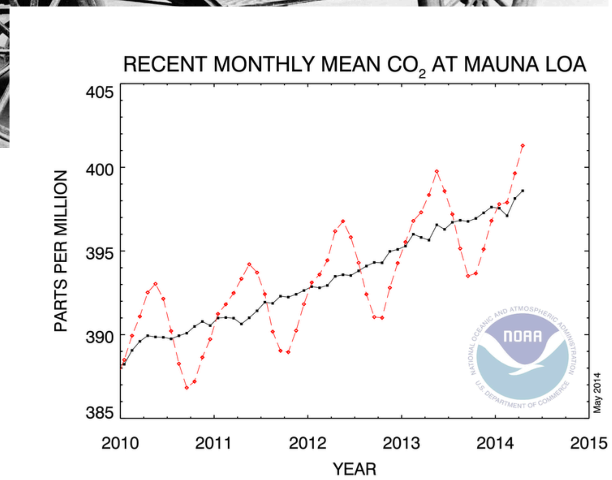
The term **'Anthropocene'** was first used by Eugene Stoermer, and subsequently popularized by the atmospheric chemist and Nobel Prize laureate Paul Crutzen (Crutzen 2002).

The Anthropocene may soon become an **official epoch**, since a proposal to formalise it was made to the Stratigraphy Commission of the Geological Society of London in 2008, resulting in serious consideration for its acceptance as an epoch in the geological time scale (Zalasiewicz et al. 2008; Zalasiewicz et al. 2010).

Crutzen (2002) dates the beginning of the Anthropocene to the late 18th century when atmospheric concentrations of **carbon dioxide** and **methane** began to rise significantly.

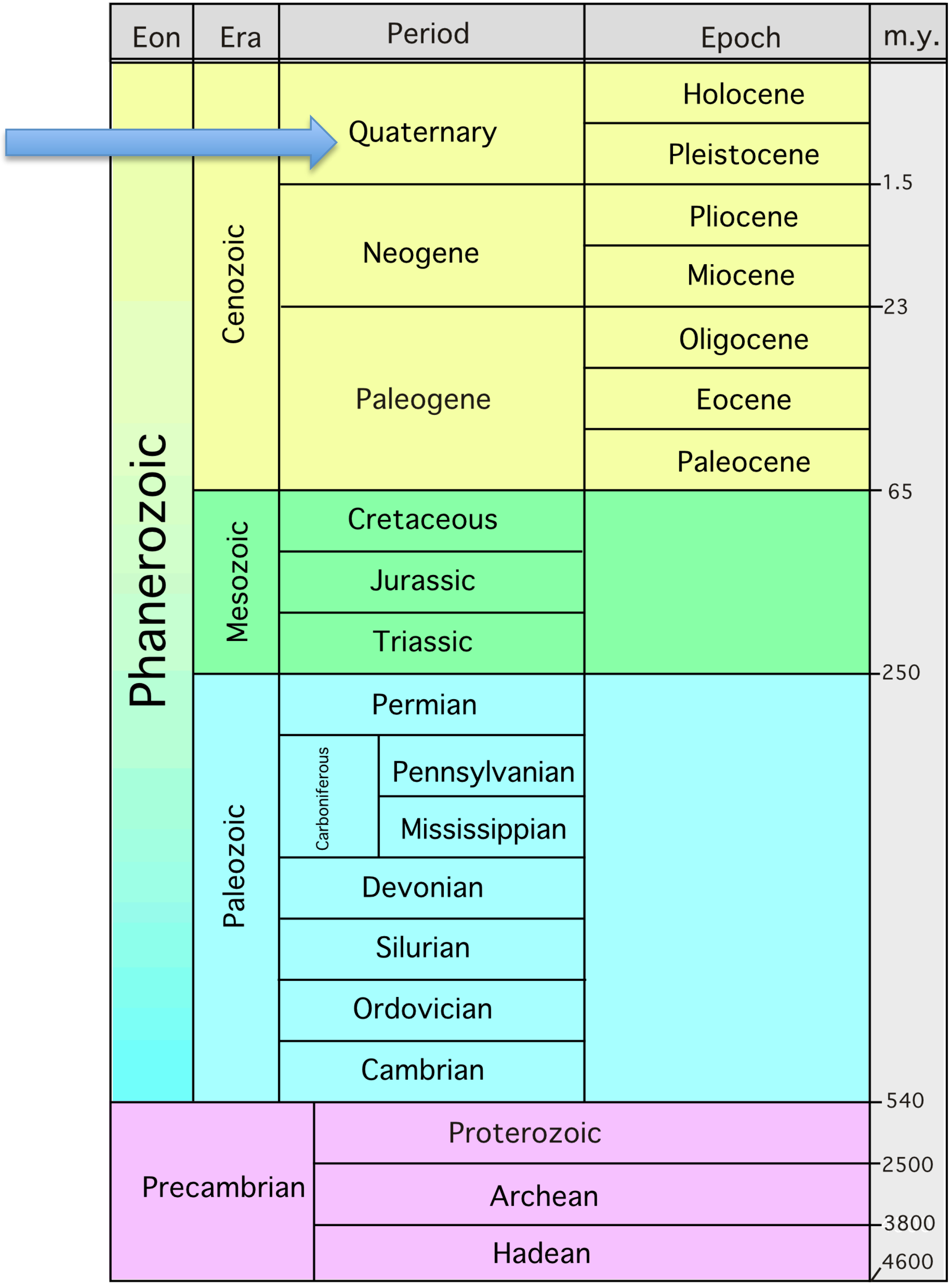
Other writers have suggested that the Anthropocene could be dated to as long as 8,000 years ago, driven by clearing of forests and agriculture (Ruddiman 2003; Ruddiman 2013). However, the **18th century** date seems a reasonable compromise, since this date coincides with the invention of the steam engine and the industrial revolution, and corresponds to increased carbon emissions by humans.



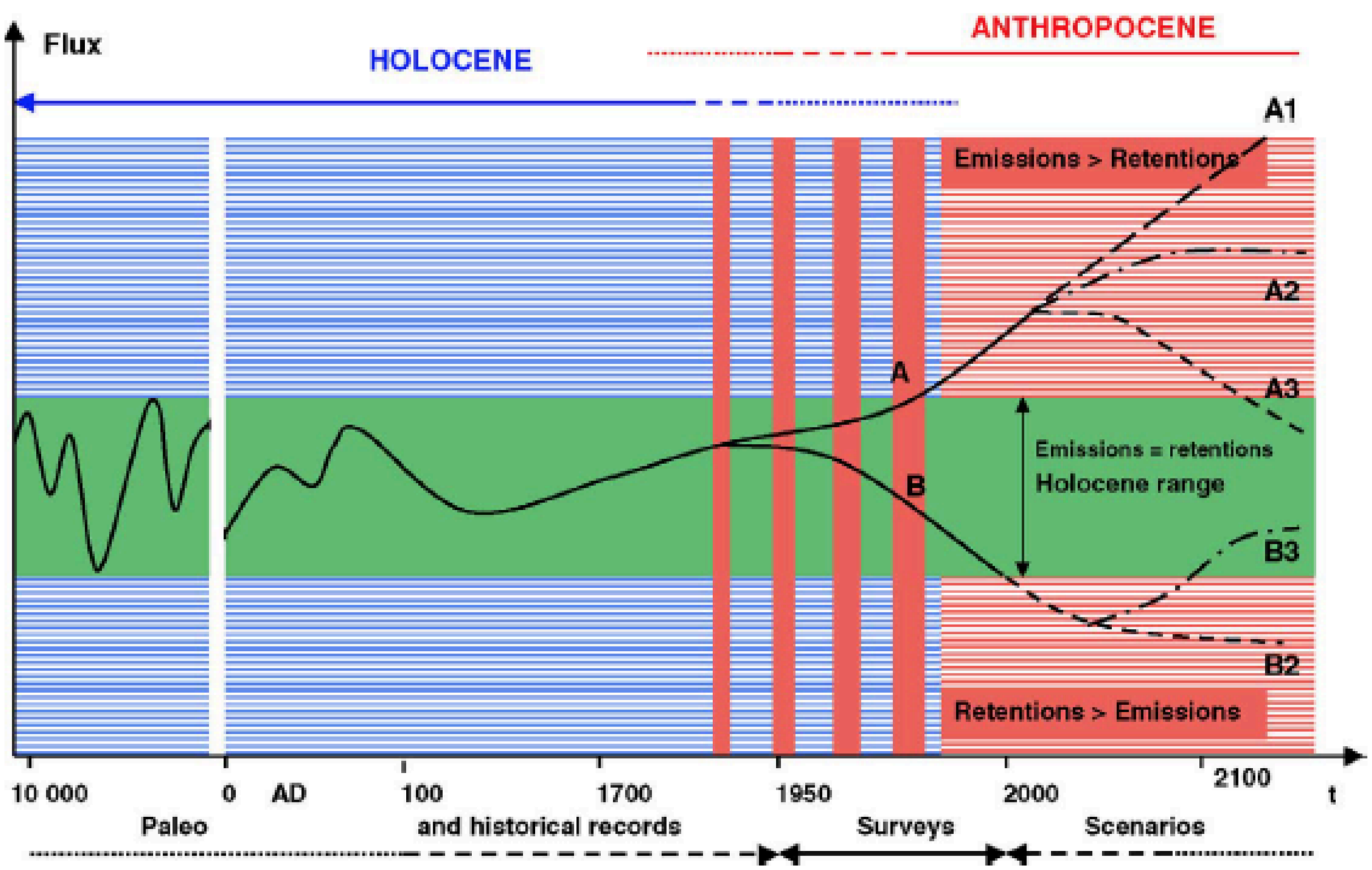


The history of Earth is divided into geological periods. The most recent period is the Quaternary, which spans the last 2.5 million years, and corresponds roughly to the time that hominids have occupied the Earth.

In turn, periods are subdivided into epochs. For instance, the Quaternary is divided into the Pleistocene and the Holocene epochs. Transitions between Periods or Epochs are defined by major geological or paleontological events that leave a signature in the geological record. Such signatures are caused by significant changes in climate, atmosphere or biota. The best-known example of such a transition is the catastrophic event that ended the Cretaceous period and coincided with the extinction of the dinosaurs.

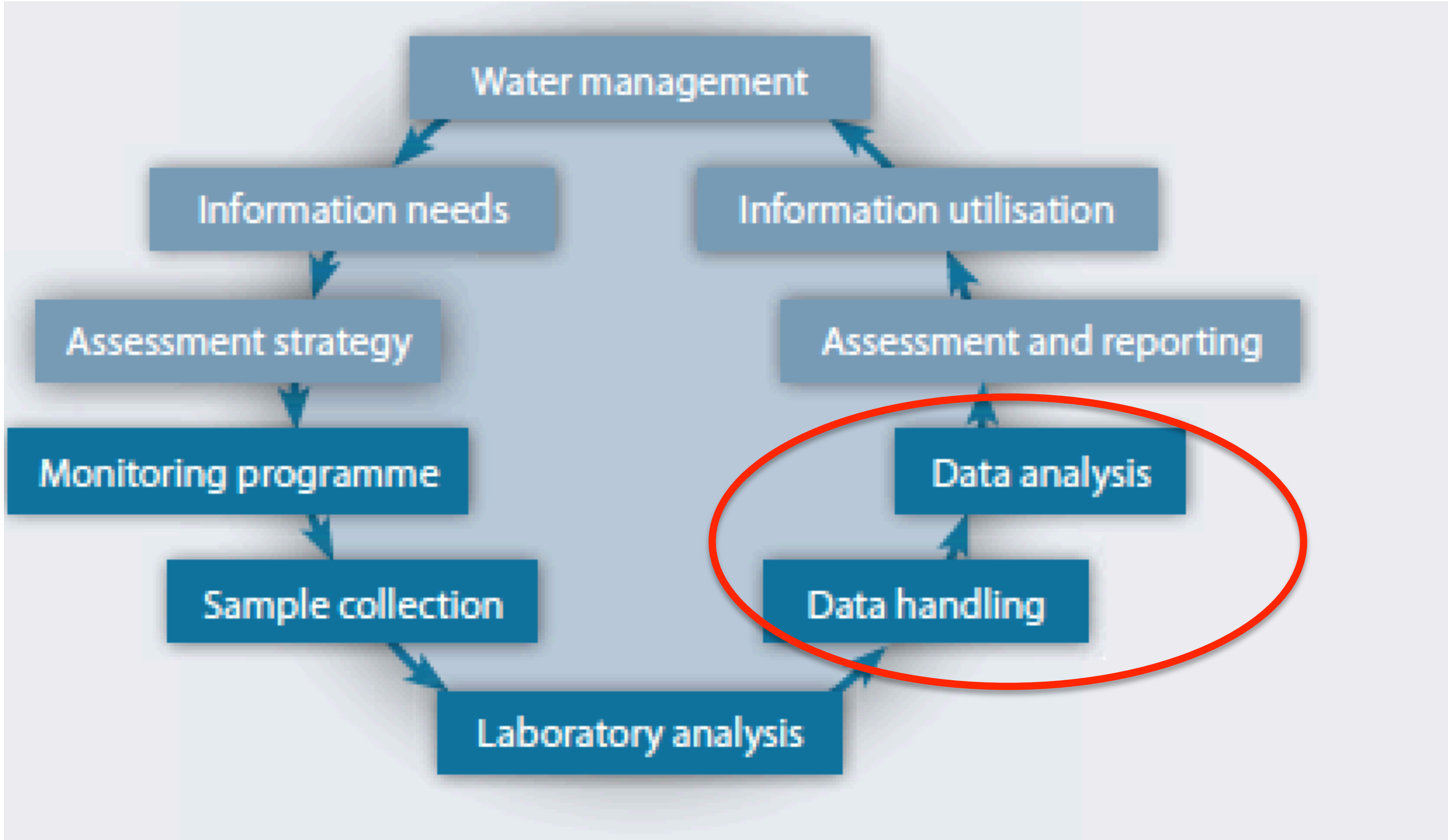


For the last 10,000 years, humans have been living in the Holocene epoch. This has been an interglacial period **of relative environmental stability**, where temperature, atmospheric conditions and biogeochemical cycles have exhibited only minor fluctuations (Dansgaard et al. 1993; Rioual et al. 2001; Young and Steffen 2009). This stability allowed humans to develop agriculture and form settled communities, culminating in the complex societies of modern times. The very stability of the Holocene has helped humans to abandon a mobile lifestyle that exploited natural resources, in favour of permanent settlements with complex infrastructure (van der Leeuw 2008).



Anthropogenic emissions generally exceed fluvial system retention (e.g., nitrogen, phosphorous) (observed trend A). Reverse Anthropocene trends (B) can be observed, as for dissolved silica or suspended material in some basins (Meybeck and Vörösmarty, 2005)

In this respect, the European Community Water Framework Directive (WFD, 2006/118/EC) was drafted with the aim to control and prevent groundwater pollution



The **Water Framework Directive** (WFD) (European Union, 2000) establishes a legal requirement for the Member States of the European Union to implement groundwater chemical and level monitoring programmes. These programmes must be designed and operated so that they can meet the needs of the WFD and its associated Groundwater Daughter Directive (GWD) (European Union, 2006), and provide reliable and comparable information on groundwater across the whole of the European Union.

WFD includes procedures to define:

i) criteria for assessing the chemical status of groundwater;

ii) criteria for identifying significant increasing trends in groundwater pollution levels;

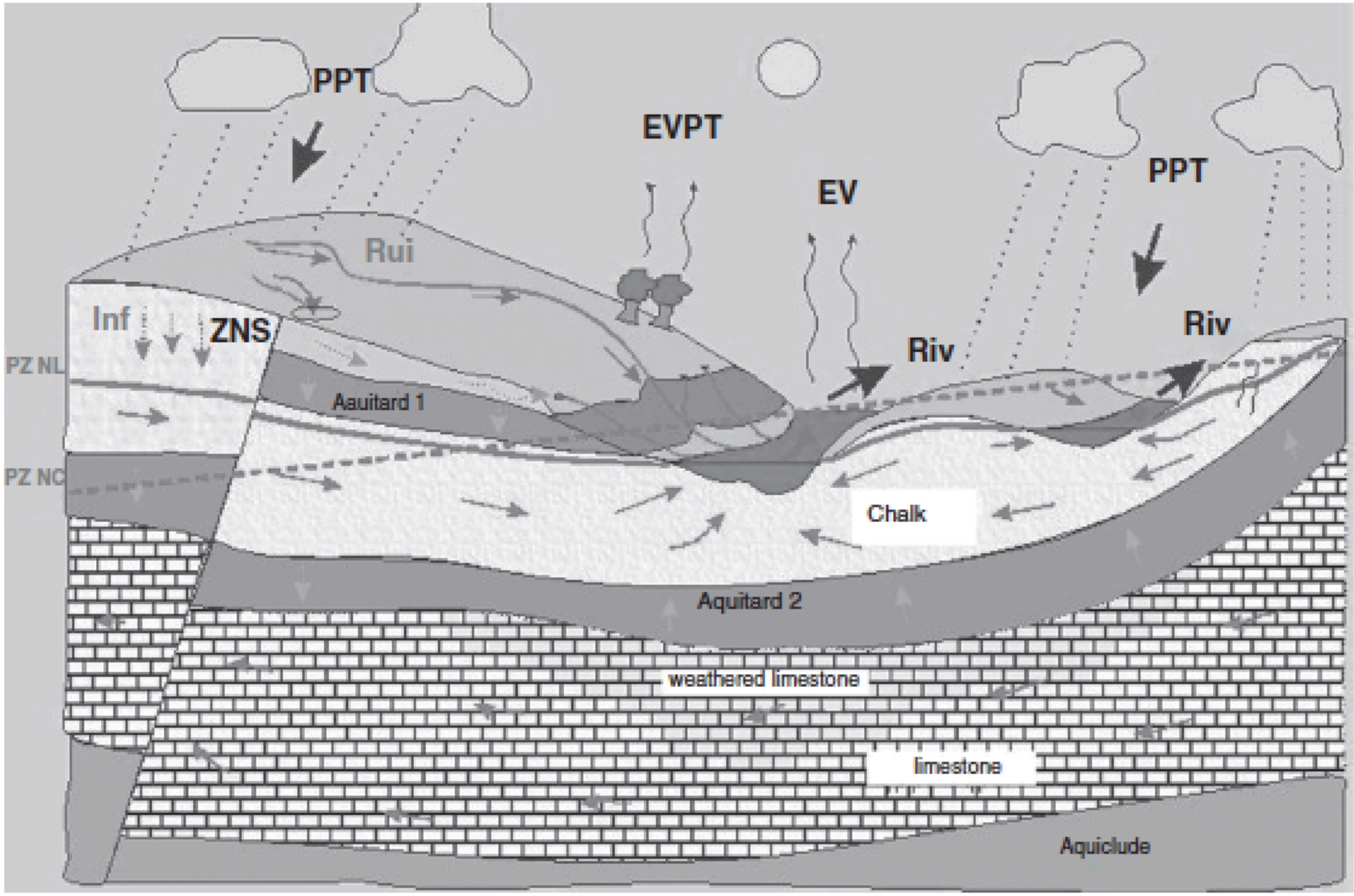
iii) actions for preventing and limiting discharges of pollutants into groundwater.

In order to design an effective monitoring programme, careful consideration must be given to the groundwater system to be monitored. **Groundwater bodies** are three-dimensional hydraulically-active systems. In many cases they are heterogeneous, with changes in property occurring over **short** distances.

Superimposed on this are physical alterations and pressures resulting from human activity. It is important therefore that all these factors are taken into account when designing monitoring programmes and that a clear understanding of the prevailing environmental conditions is developed.

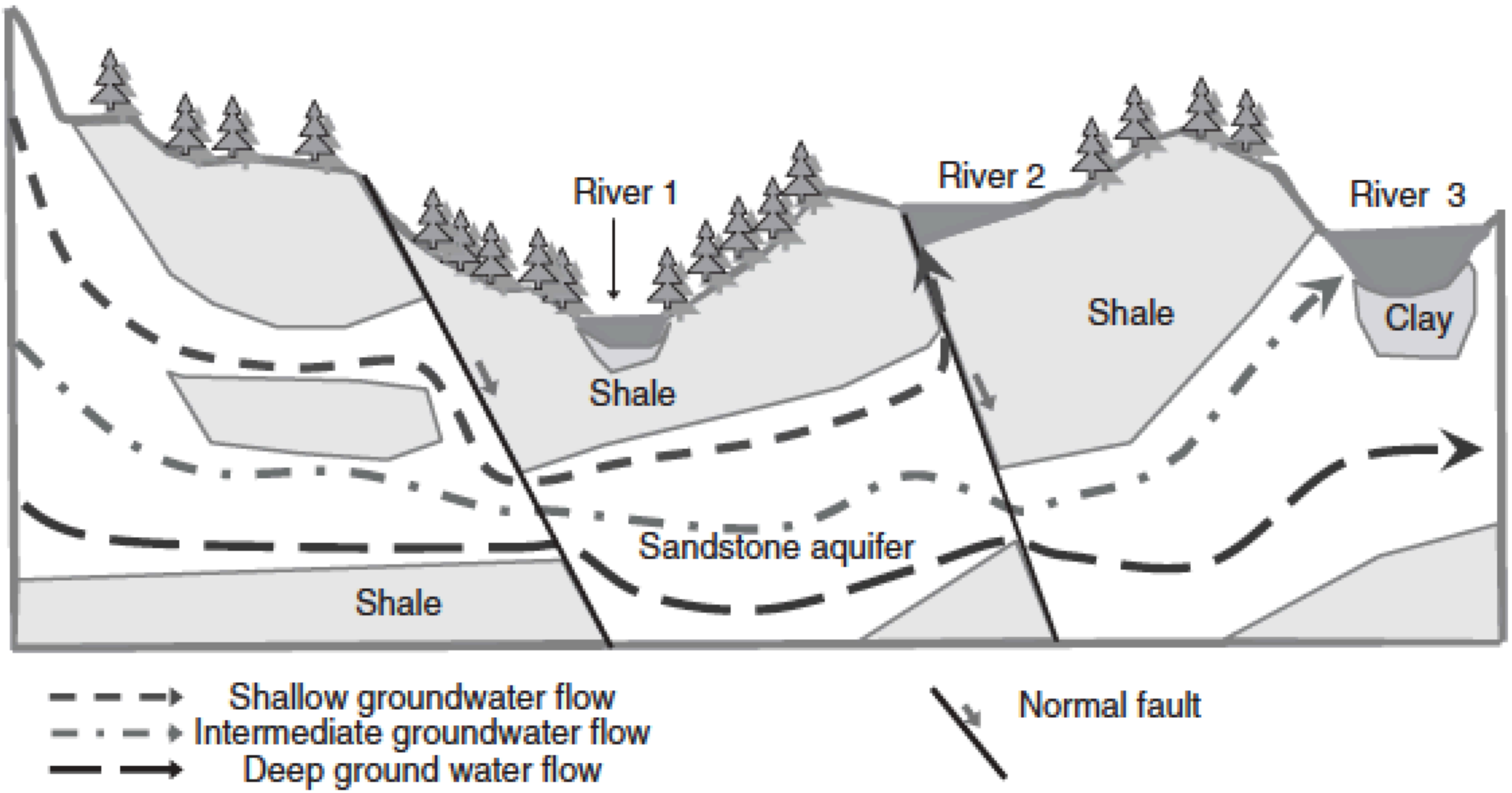
This understanding is referred to as the **conceptual model**.

Conceptual models are simplified representations, or working descriptions, of the hydrogeological system (groundwater body) to be investigated and monitored.

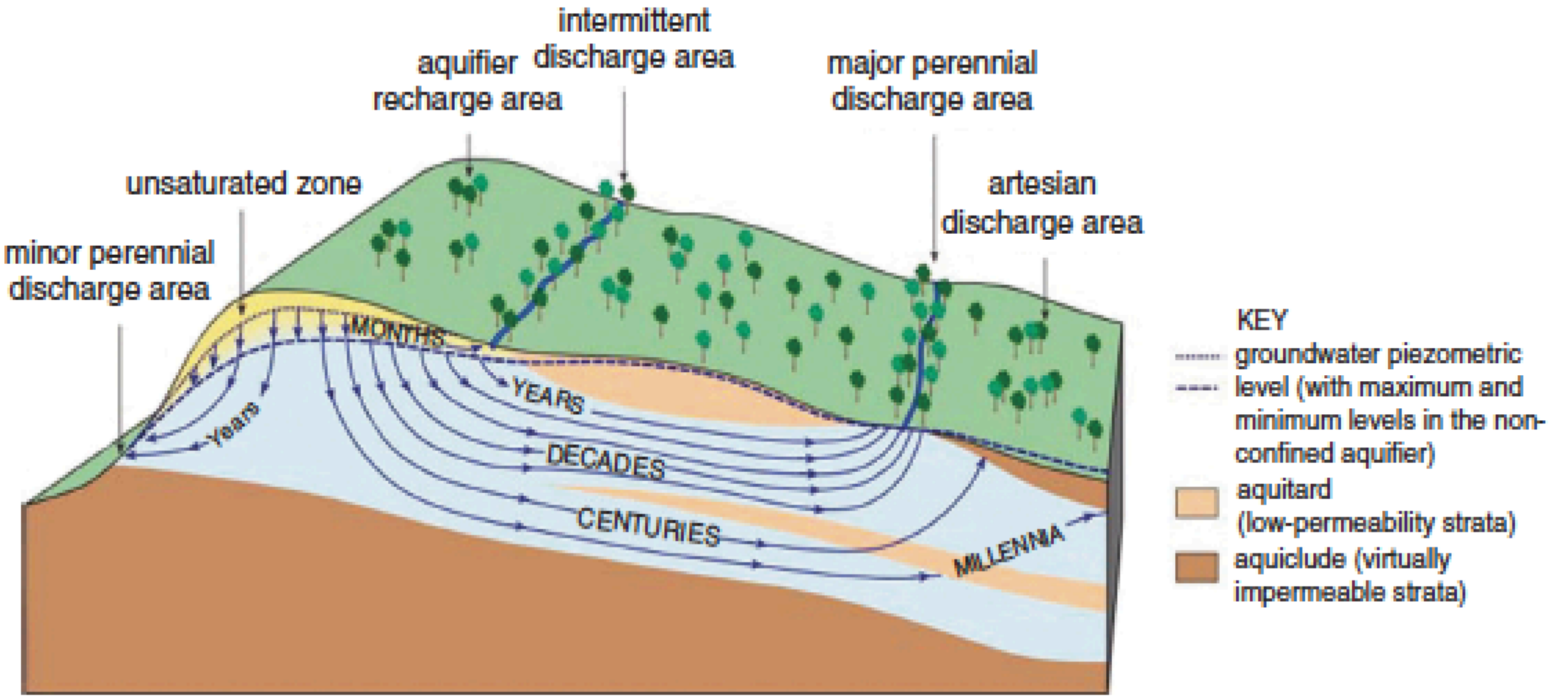


Typical groundwater flow in a lowland sedimentary aquifer system

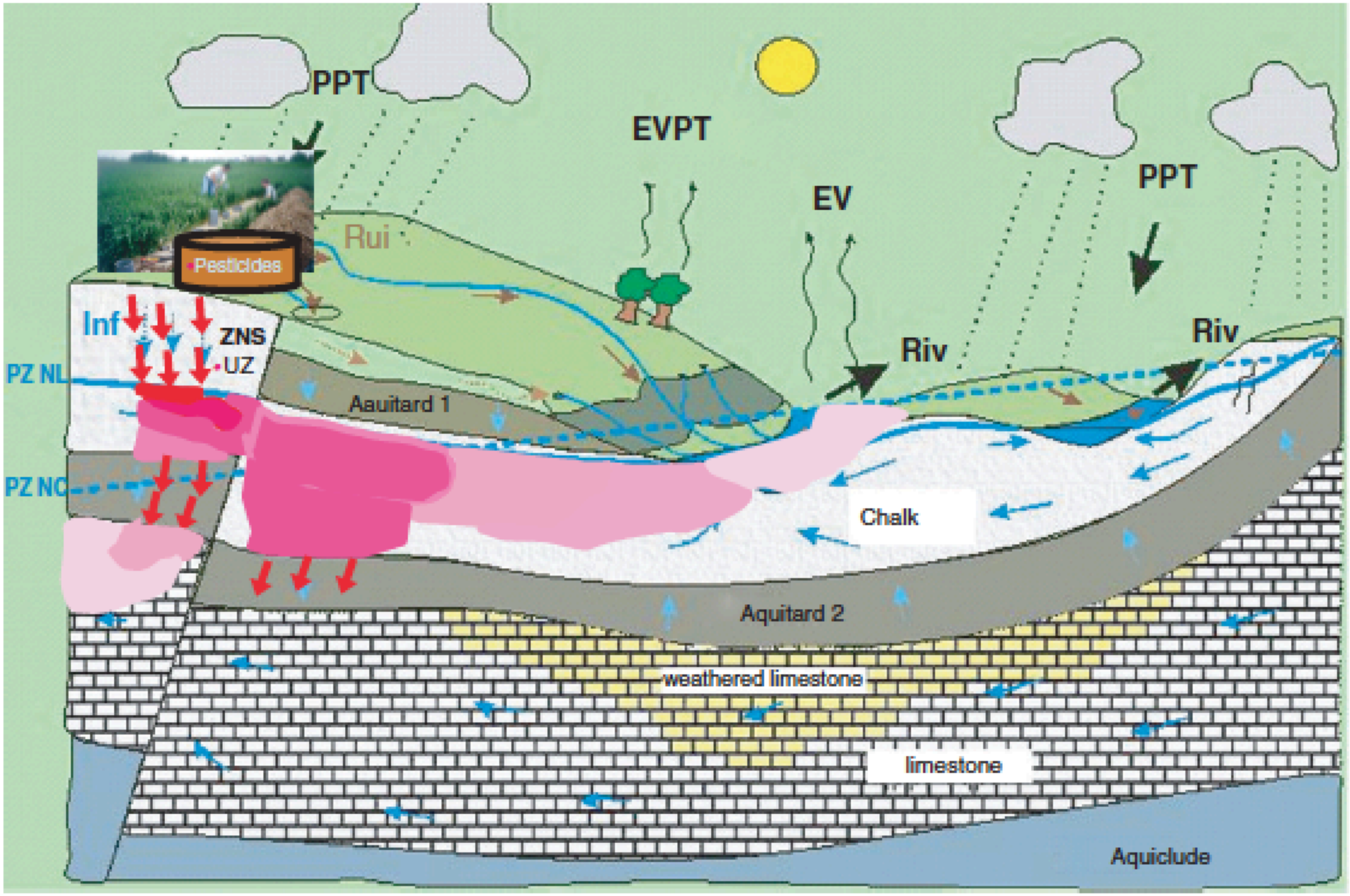
Basically **groundwater flows** in a subhorizontal direction in aquifers (here a chalk and a limestone) and subvertically through the unsaturated zone (= infiltration between the ground surface and the watertable - PZ NL) and the aquitards. The hydraulic head difference between the upper unconfined chalk (PZ NL) and the deeper confined limestone (PZ NC) drives and orientates the flow exchange between the two aquifers (PPT: precipitations; EVTP: evapotranspiration; EV: evaporation; INF: infiltration; ZNS: unsaturated zone)



Groundwater flow is often strongly influenced by geologic heterogeneities and discontinuities. This example from a mountain area **shows tortuous flow lines**, which tend to adapt their orientation in order to travel preferentially through areas of greater permeability. This process can bring shallow, intermediate and deeper groundwater to have different flow paths and discharge areas, as shown in the figure. In this case, shallow groundwater discharges into River 2 after having seeped upward through a permeable normal fault, while intermediate groundwater feeds River 3 further eastward, and deep groundwater continues its subsurface flow to the east beyond River 3.

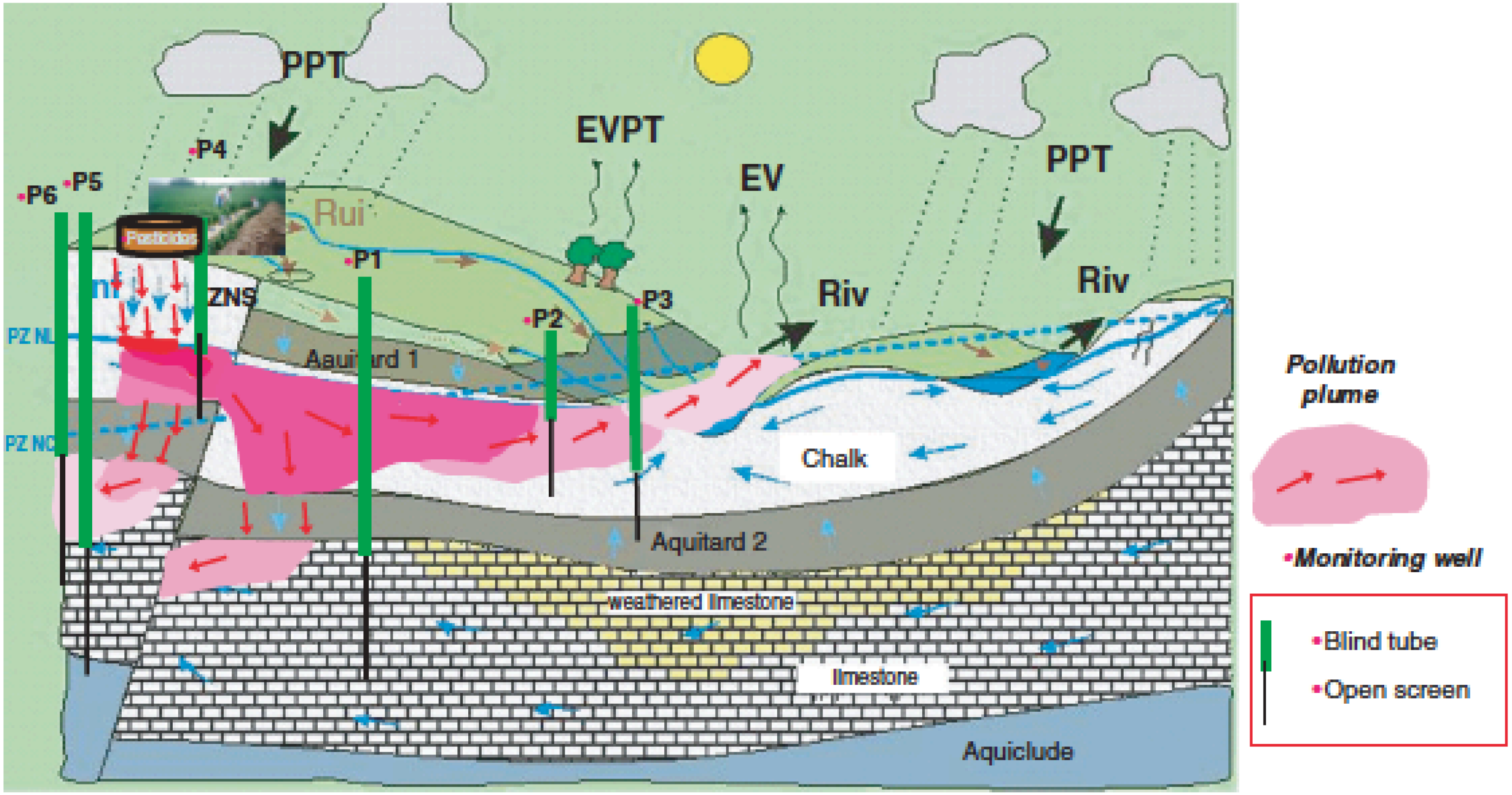


In large aquifer systems, shallow, intermediate and deep **groundwater flow paths** may **vary significantly**. Close to the ground surface, groundwater travel from recharge to the discharge areas may take only several years, while decades, centuries or more may be needed for deep groundwater circulation. This often results in different inertias and residence times for shallow, intermediate and deep groundwater. In addition, water quality may significantly differ from the top to the bottom of the aquifer system, due to flow paths crossing different geologic layers and to varying degrees of water–rock interaction (increased water–rock interaction often results in more mineralized water at depth) (Foster and Gomez, 1990).

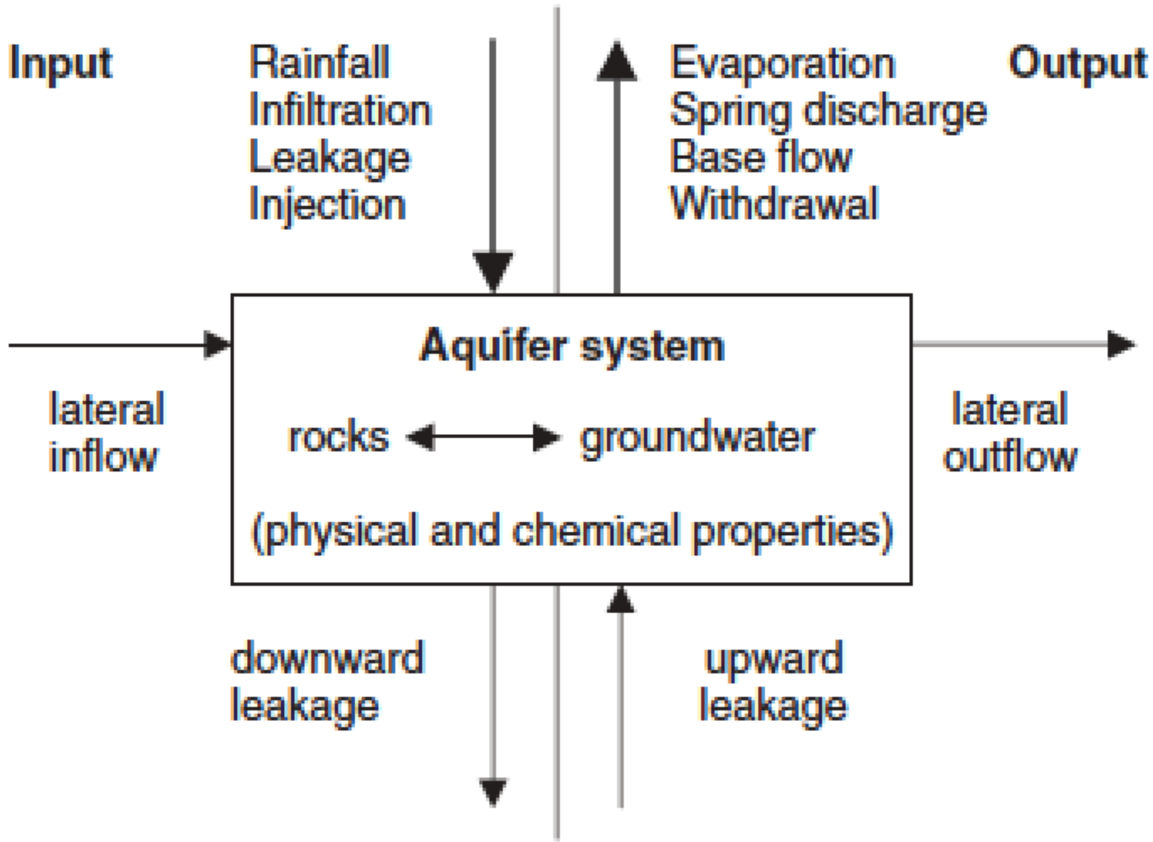


The **main driving mechanism** for pollutant transport below the ground surface is [groundwater flow](#).

Basically, contaminants **migrate downward** through the unsaturated zone to reach the water table (the groundwater surface). Once they penetrate into the shallow aquifer, their transport to the discharge areas is subhorizontal. Subvertical seepage through the aquitards may further occur according to hydraulic gradients and flow direction.

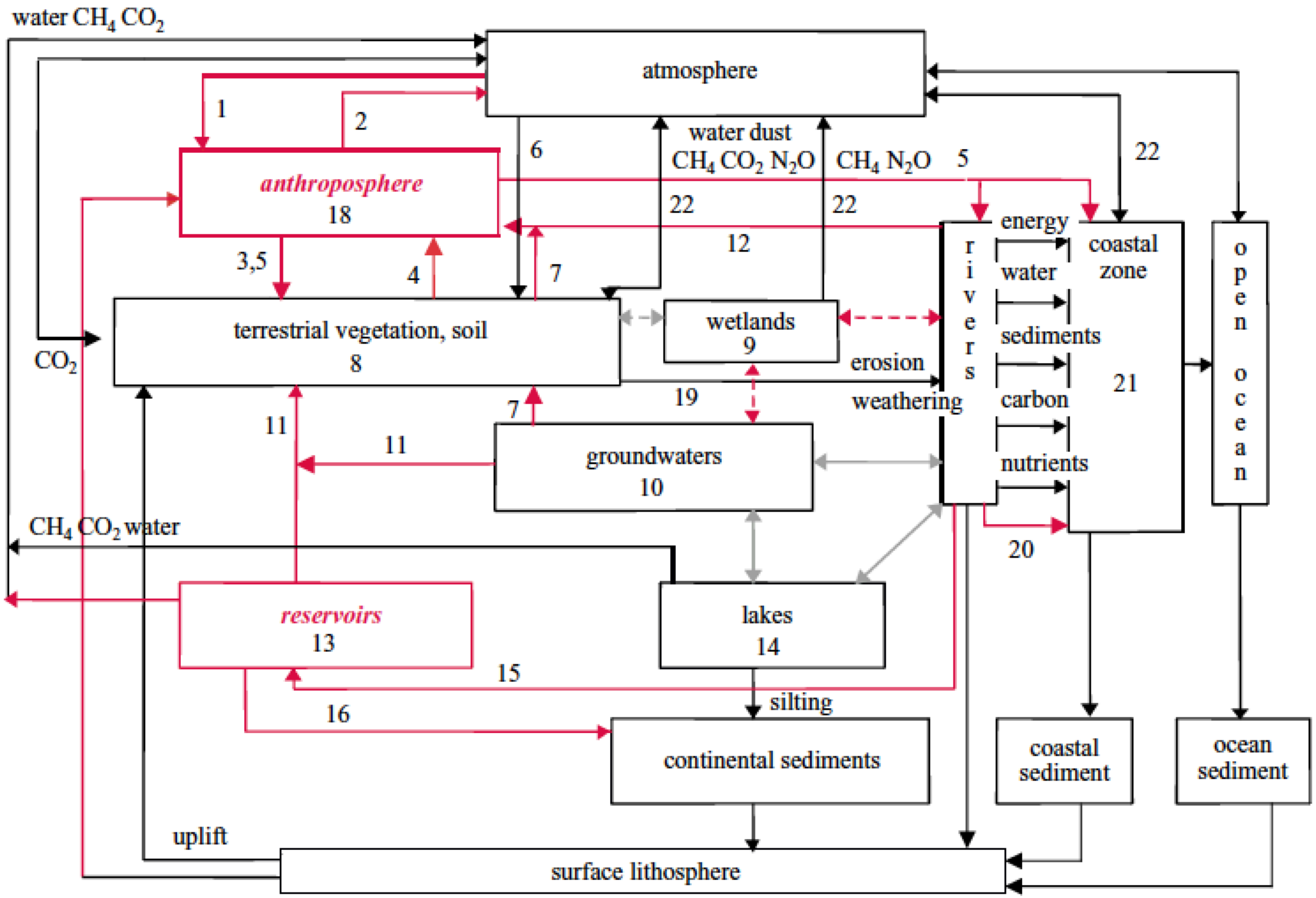


If a pollution source is persistent, pollutants may eventually cross through most aquitards and **contaminate** the down-flow areas of deeper aquifers



Conceptual framework of the complex system of groundwater and aquifer formations

Continental aquatic systems in the present day Earth system



Black, natural fluxes and pathways of material; red, major impacts of human activities: 1 = N fixation; 2 = water consumption; 3 = fertilization; 4 =food and fibre consumption; 5 = waste release; 6 = atmospheric pollutants fallout; 7 = water abstraction; 8 = land use (deforestation, cropping, urbanization); 9 = draining; 10 = salinization, contamination, depletion; 11 = irrigation; 12 = diversion; 13 = evaporation, regulation, eutrophication; 14 = eutrophication; 15 = damming, water storage, diversion; 16 = silting; 17 = mining; 18 = industrial transformation; 19 = enhanced soil erosion; 20 = xenobiotic fluxes; 21 = changes of inputs to coastal zone; 22 = changes in greenhouse gas emissions.

In the European Union (EU), the **Water Framework Directive** (WFD) (European Community, 2000) will provide the basis for EU water legislation for many years to come and will determine the way in which concentrations of chemicals in the aquatic environment are monitored and regulated (Crane, 2003).

HOW TO ACCOUNT FOR NATURAL BACKGROUND LEVELS?

In Europe, with exception of some remote and unpopulated areas, unaltered natural background concentrations are infrequently observed in surface waters as a result of both historical and current anthropogenic input.

Therefore, the term **'baseline concentration'** is often used to express ***the concentration in the present or past corresponding to very low anthropogenic pressure***.

The baseline concentration is the **sum** of the **natural background** and the **fraction** of chemicals that has been historically introduced to (or removed from) the environment by man over time (decades to centuries). The added fraction is often referred to as ***historical contamination***. In many cases this historical contamination cannot be distinguished from the natural background concentration.

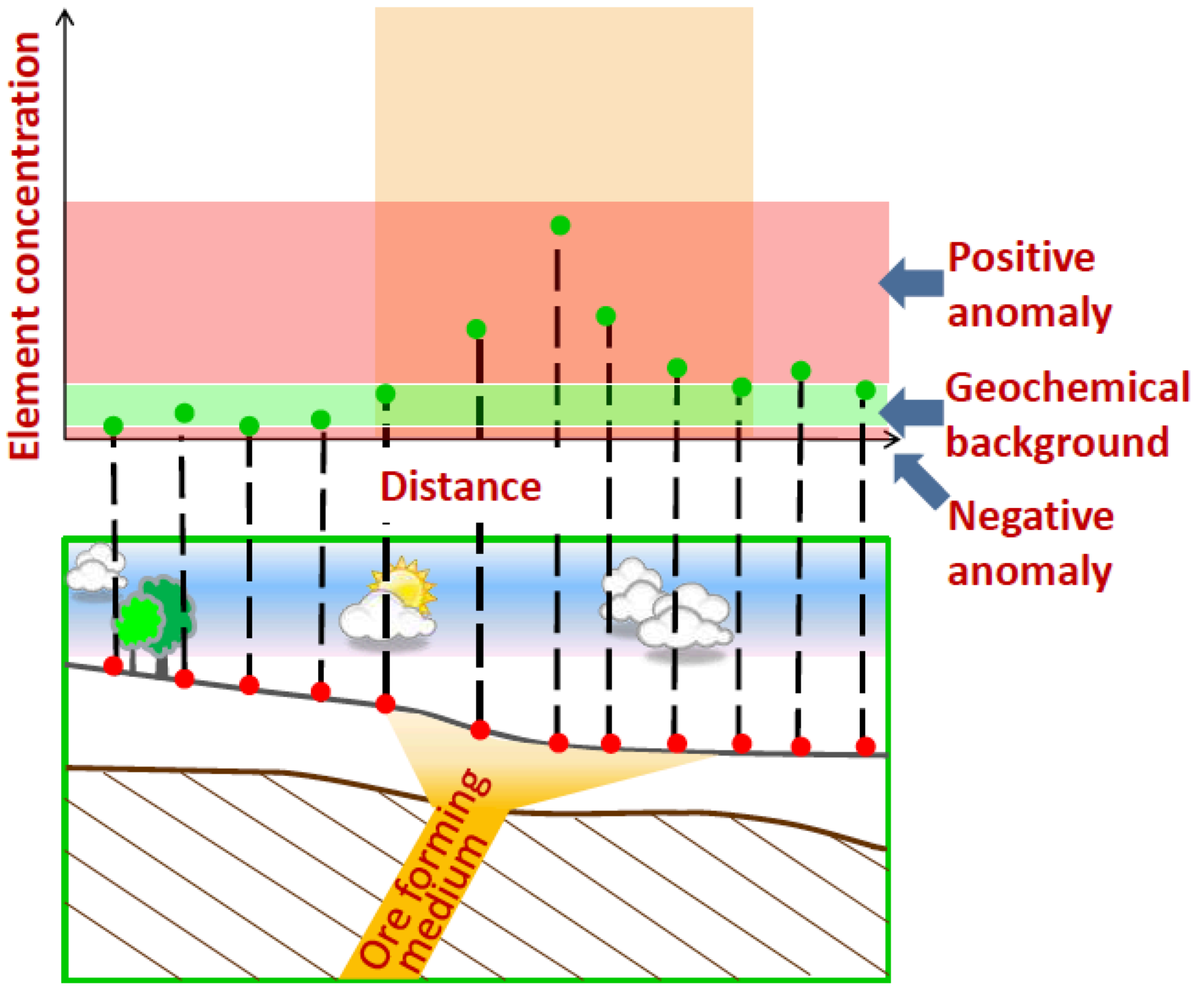
The term **"geochemical background"** was originally introduced by exploration geochemists in the mid 20th century to differentiate between the abundance of an element in unmineralized and mineralized rock formations.

During the last few decades "geochemical background" has become one of the most **crucial terms** in environmental sciences. It is sometimes used to distinguish anthropogenic input (pollution) from natural (geogenic and/or biogenic) concentrations of elements in different environmental samples.

The adoption of the term "geochemical background" for environmental sciences has resulted in broadening its meaning and application to different materials. At present "geochemical background" is applied **not only** to rocks, minerals and sediments, but also to water, air, and even to plants despite many constraints put on the selection of specific samples.

The term ***"geochemical baseline"*** is often used as a synonym of "geochemical background" . Originally, it was used by Tidball et al. (1974) in a study on the influence of a coal-fired powerplant on the environment in the Powder River Basin (Montana and Wyoming) and it was defined as ***"a natural background in a heavily anthropogenically polluted area."***

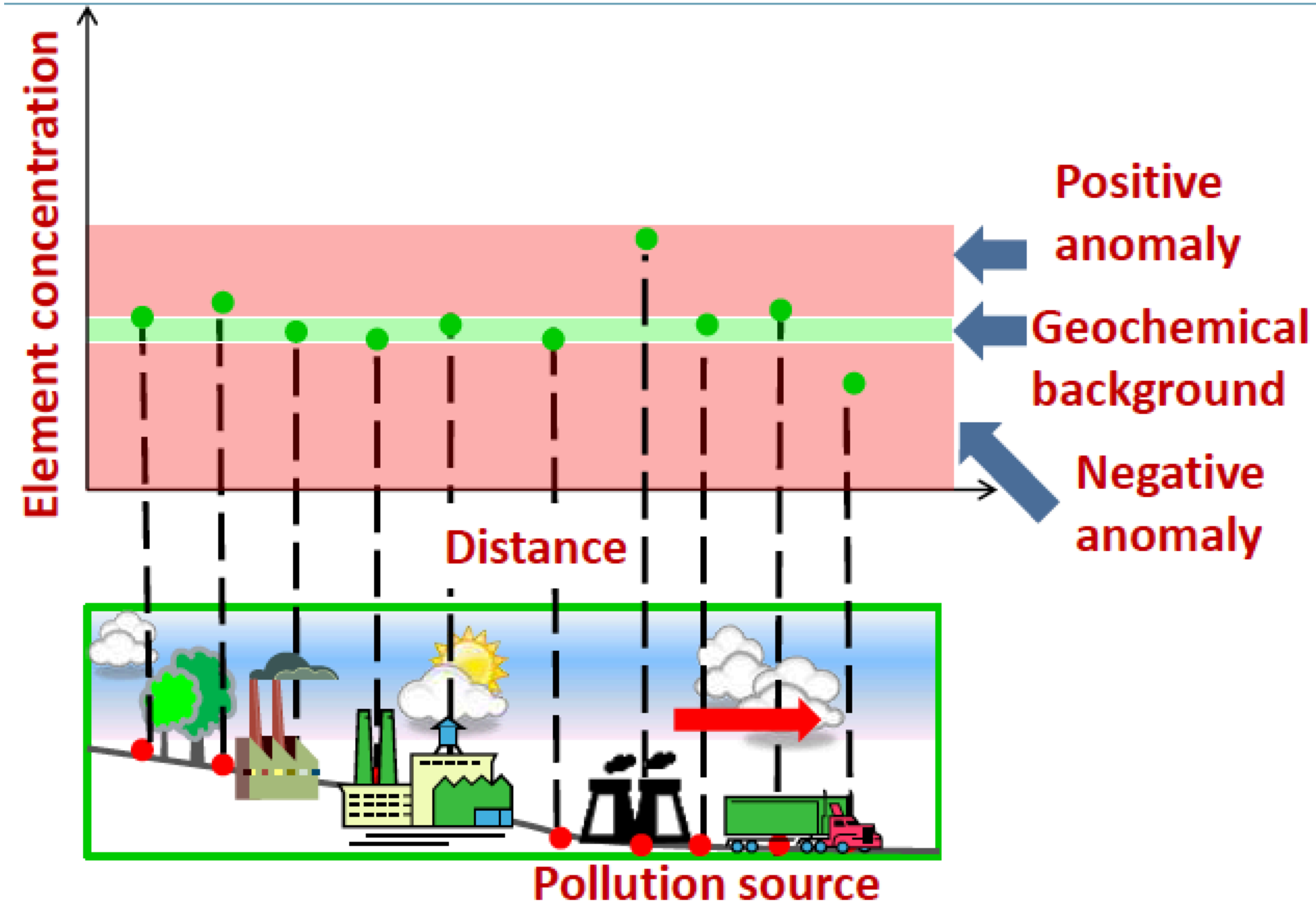
Historical use of the term "geochemical background" in **exploratory geochemistry** and **geochemical prospecting**.



Hawkes, Webb (1962): "the normal abundance of an element in barren earth material" – a lack of anomaly

GEOCHEMICAL PROSPECTING SEARCH FOR **POSITIVE** ANOMALIES

Environmental approach: geochemical background is a ***relative measure*** to distinguish between natural element or compound concentrations and anthropogenically-influenced concentrations in real sample collectives" – a lack of man-made pollution (Matschullat et al., 2000).



Polish J. of Environ. Stud. Vol. 16, No. 3 (2007), 389-395

Original Research

Different Approaches in Using and Understanding the Term "Geochemical Background" – Practical Implications for Environmental Studies

A. Gałuszka*

Different variants of "geochemical background" used in the literature

Variant	Meaning
Ambient background	"The concentrations of naturally occurring inorganic substances and ubiquitous anthropogenic inorganic substances in the environment that are representative of the region surrounding the site and not attributable to an identifiable release".
Anthropogenic background	"Concentrations typically observed in a region that are the result of human activities but that are not associated with a specific contamination activity". "Chemicals present in the environment due to human activities that are not related to specific point sources or site releases".
Area background	"The concentrations of hazardous substances that are consistently present in the environment in the vicinity of a site which are the result of human activities unrelated to releases from that site".
Natural background	"The amount of naturally occurring substances in the environment, exclusive of those from anthropogenic sources". "The concentration of hazardous substance consistently present in the environment that has not been influenced by localized human activities".
Naturally occurring background	"Ambient concentrations of chemicals present in the environment that have not been influenced by human activity".
Pedogeochemical background	"Natural concentrations of elements in soils".
Pre-industrial background	"… is sometimes used when data either come from age-dated materials or are collected from areas believed to represent survey/study area in its supposed 'preindustrialization' state".

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Original Research

Different Approaches in Using and Understanding the Term "Geochemical Background" – Practical Implications for Environmental Studies

A. Gałuszka*

Different approaches to the background evaluation with short characterization

Approach	Aspect/technique	Background expression	Principal requirements
Direct (geochemical)	Historical aspect; Contemporary aspect	Mean or median (single values)	Not anthropogenically influenced samples
Indirect (statistical)	Regression analysis; Fractal method; Probability plots; Techniques used to eliminate the outliers	Range of values	Large datasets
Integrated	–	Upper limit of the range of values	Pristine areas for sample collection. Expert knowledge

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Geochemical background—concept and reality

Clemens Reimann[a,*], Robert G. Garrett[b]

"..It is important that regulators recognize that background **depends** on location and scale. It **changes** from area to area and with the scale of the area investigated. When mapping at the continental scale, natural element concentrations can be as high or even higher than any visible anthropogenic contamination. Natural variation of element concentrations in different environmental sample materials will often be so large that it is difficult to identify anthropogenic additions, contamination, in other than gross cases"

"…background is a range, not a single value".

Is it possible to consider the concept of **compositional background**?