Geo Factsheet

Number 79

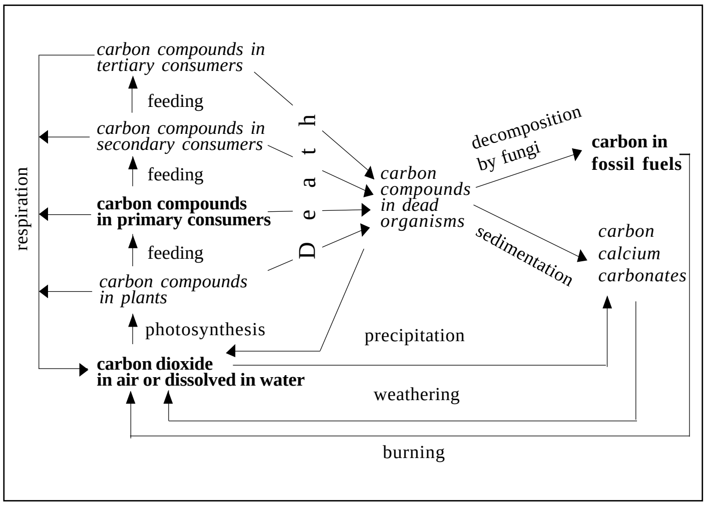
Human effect on Nutrient Cycles

Carbon
Humans have been interfering with the natural carbon cycle for thousands of years. However, up until 1850 anthropogenic (man-made) emissions of carbon dioxide were insignificant compared to the natural fluctuations of the carbon cycle. However, in the last 150 years the scale of impact has increased considerably. There are two main ways in which humans have done this:

1. By hugely increasing the combustion of fossil fuels, all of which, by definition, contain carbon.
2. By changing land use, particularly through deforestation.

Fig 1 shows the carbon cycle.

Fig 1. The carbon cycle



1. Burning fossil fuels
The fossil fuel which we burn took at least 1000 years to form (peat) but most (e.g. coal) took millions of years. Industrialisation of North America, Europe and Japan required energy, the vast majority of which has come from fossil fuels. Similarly, the modernisation of Asian, Middle Eastern, Latin American and African economies continues to be fossil fuel dependent. (Fig 2)

The direct consequence of this is that fossil fuel carbon stores are **decreasing** and atmospheric levels of CO_2 are **increasing**. Annually, humans add 7Gt of carbon from fossil fuels and burned vegetation to the atmosphere – 3Gt of which stays there, i.e. is not removed by plants in photosynthesis. The consequence of this is that the temperature of the lower atmosphere (troposphere) is rising – CO_2 is a greenhouse gas, i.e. it traps outgoing radiation.

The consequences of the enhanced greenhouse effect will be global and, in very many cases, harmful.

***Exam Hint** - Make sure you **understand** what effect humans are having on each of the three bold points in the carbon cycle in Fig 1.*

Feedback mechanisms will complicate matters. The most important are:

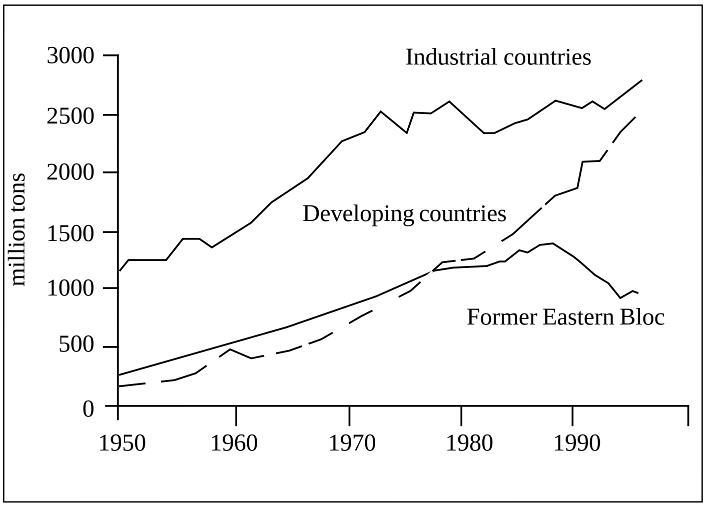
1. Temperature rise on land will be greater than the temperature rise of the oceans (because water has a higher heat capacity). So the temperature gradient between land and oceans, especially at the poles will increase.

2. More ice and snow will melt so more land and ocean will be exposed to sunlight. These darker surfaces will absorb more heat and, in turn, reradiate more. This will amplify the warming which will lead to more ice and snow melt and so on...

3. In arid areas the additional energy absorbed by soil will increase reradiation, hence heating of the air. The warmer air will further reduce any cloud formation so areas which already experience very low rainfall may become even drier. This could increase **desertification.**

4. Greater evaporation will increase cloudiness. These will reflect more sunlight, reducing the amount of energy reaching the ground so this will have a cooling effect.

Fig 2. Carbon emissions from fossil fuel burning



2. Land use change
The major changes in land use practices interfere with the carbon cycle are as follows:

i. Conversion of forest and wetland to grassland and pasture. Forests store 50-100 times as much carbon as crops. Wetlands are highly productive and therefore important carbon sinks.

ii. Urbanisation

iii. Grassland fires by pastoralists and peasants.

It is estimated that the net annual release of carbon from land use change is about 150Gt of which 125Gt reaches the atmosphere (Fig 3).

Fig 3. Carbon emissions from land use change

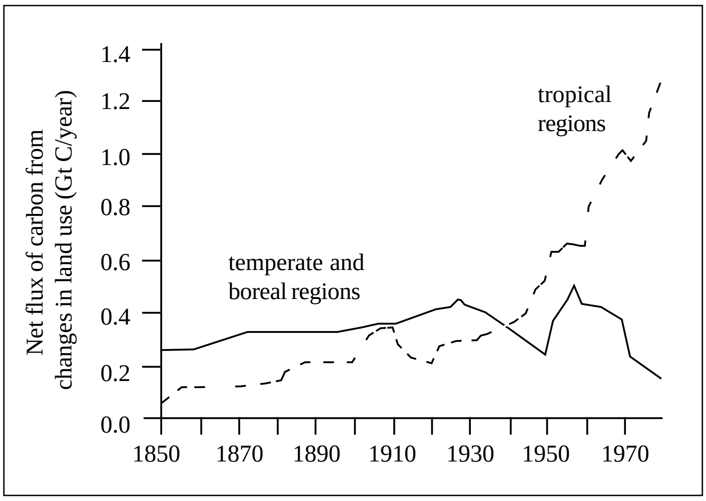


Table 1. Sources of fixed nitrogen

Source	Quantity (tg/year)	As % of N_2 fixed
Natural sources		
lightning	< 10	3
microbes	90-140	34
Human sources		
nitrogen fertilizer	80	24
leguminous crops	32-53	13
Release of previously fixed nitrogen		
burning fossil fules	20	6
clearing land, draining wetlands	70	21
Total human fixation and release	213	63

Nitrogen

Humans began interfering with the natural nitrogen cycle when organised agriculture began, but until this century the scale of human impact was negligible. This changed dramatically with the development of the industrial synthesis of ammonia from nitrogen. This led the way for the development of intensive agriculture based upon artificial nitrogen fertilisers. In addition, 10% of the world's croplands are planted with legumes – plants which can naturally fix nitrogen, i.e. they convert the atmospheric gas into ammonia gas which after transformation can then be utilised by plants.

The major impact of humans on the natural nitrogen cycle is therefore via fertilisers and legumes (Table1). If all of the nitrogen ended up in natural vegetation and crops there would be little problem. But it doesn't – a substantial proportion ends up in underground water stores (aquifers), in the rivers, lakes or oceans, or in altered forms in the atmosphere. In each of these areas the nitrogen causes environmental problems. (Fig 4)

Sulphur

The two major human impacts on the sulphur cycle are the combustion of fossil fuels which contain sulphur and the production of copper. Both release gaseous SO_2 – a component of acid rain. Perhaps ironically, sulphate aerosols reflect incoming solar radiation, thus actually decreasing the amount of energy which reaches the lower atmosphere. Thus, human-generated sulphur pollution actually helps to decrease the enhanced greenhouse effect.

Acid Rain – Simple Chemistry

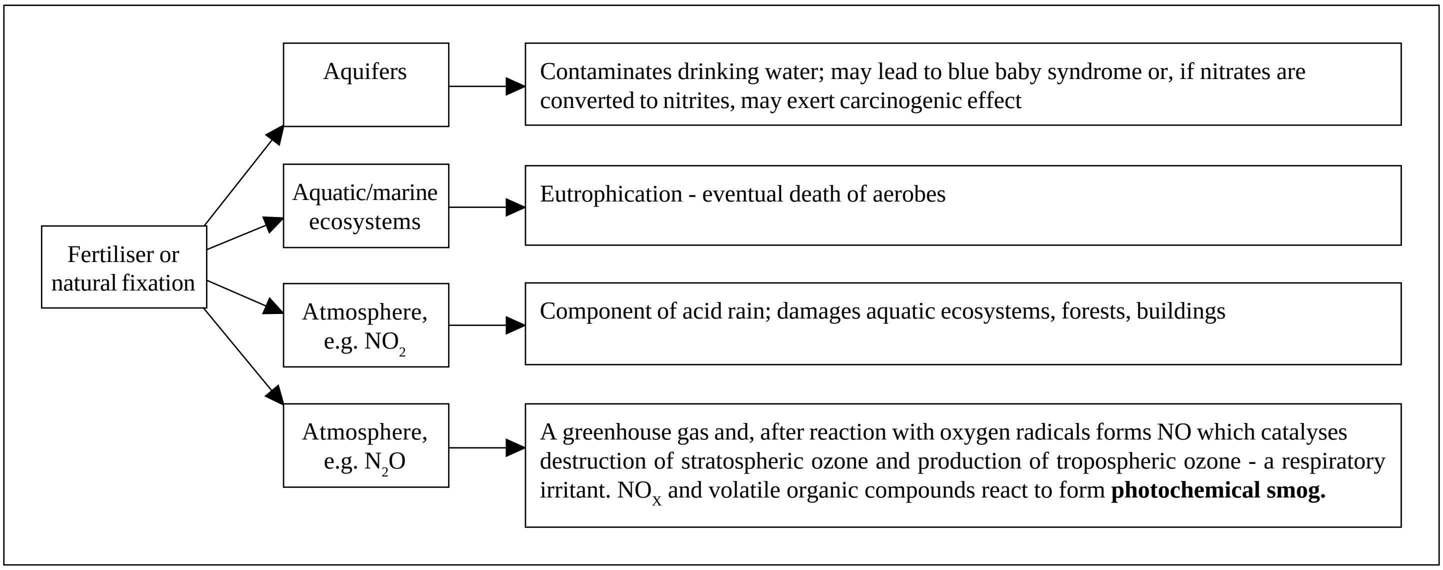
Coal and oil contain carbon, nitrogen and sulphur. Burning them converts them into dioxides, which are released into the atmosphere. All three dissolve in atmospheric moisture to form carbonic, nitric and sulphuric acids respectively. Rain is naturally acid (pH 5.6), because CO_2 is a natural component of the atmosphere. When sulphuric and nitric acids are added, the pH may fall to 4.

Acid rain is a **transboundary** pollutant. Sulphate particles are frequently carried 500km within 24 hours e.g. from central Europe to Sweden. However, most European countries are both sources and recipients of acid rain. Much acid rain is neutralised naturally by alkaline soils and particles. This may be one of the reasons that China - by far the largest producer of coal in the world - has not suffered more damage from acidification; China's deserts, deforested mountains and eroding plains provide huge amounts of alkaline material.

In Europe the regions of highest acidic deposition include Poland and the former Czech Republic. In the UK, France and Germany, attempts to cut SO_2 emissions have already begun to have a positive effect and the average acidity of rainfall is decreasing. Despite this, acid precipitation has devastated many ecosystems and still causes huge economic and environmental problems including:

- Accelerated weathering of buildings, monuments etc.
- Death/reduced productivity of forests, crops
- Soil acidification-reduced fertility
- Aluminium ions going into solution which leach into aquatic ecosystems, killing invertebrates and fish.

Fig 4. The harmful effects of disturbance of the nitrogen cycle



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