Materials

Raw materials

To achieve even a basic standard of living, people need access to a certain amount of various raw materials — as a minimum, sufficient to make tools and clothing, provide shelter and grow food. In industrialized economies, the range and quantity of materials exploited are extensive, and in most cases large amounts of energy are also used in extraction and production processes. Anyone concerned with the future of life on this planet ought to be aware of the range and quantity of raw materials from which the vast number of products created by industrial economies are made.

Renewable and non-renewable materials

Some of these materials, minerals in particular, are non-renewable. Once used, resources are only renewed over a geological timeframe of millions of years. For the purposes of our species, they simply cease to exist. Others — especially those derived from biomass (plants, animals and other living things) — are usually renewable in principle. This means that, to some extent, they can continue to be exploited on an ongoing basis. But being renewable does not imply unlimited availability. Renewable resources cannot continue to be used beyond the rate at which they are regenerated.

This is, of course, what “sustainability” means. Stocks of biological capital that may have taken thousands, if not millions, of years to accumulate are all too often used far more rapidly than they could ever be renewed. This can lead to the sudden unavailability of raw materials upon which people have come to rely. In the worst cases, over-exploitation also destroys the ecosystems from which materials arise — in which case the over-exploitation becomes irreversible, and the materials cease to be renewable.

The consequences of unsustainable exploitation of renewable materials are particularly harmful when those exploiting them are unaware of the threat their actions pose to vulnerable ecosystems, or if they are either unable or unwilling to reduce their exploitation and consumption.

Timber and deforestation

Timber and forests are a prime example of over-exploited renewable resources. Since prehistoric times people have used wood for fuel, to make tools and shelter and, until the 19th century, timber was the principal material for shipbuilding. Since as long ago as Roman times, demand for timber has resulted in local and regional deforestation, with a consequent reduction in the amount subsequently available. Likewise, demand for agricultural land has long been a cause of deforestation.

With the rapid increase of human population through the 20th century, the problem has escalated, with serious knock-on effects in terms of habitat loss and reduction in biodiversity. Forests are also important to the climate, because they absorb carbon dioxide and therefore help mitigate the global warming effect of burning fossil fuels. Destruction of forests

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therefore makes the problem of climate change worse.

Fossil fuels

Oil and other fossil fuels are another important case, though in this instance the resource is non-renewable. Not only are fossil fuels — oil in particular — sources of much of the energy we use for specific purposes (e.g. air travel), but they are also the raw material for petrochemical products. These include most of the plastics that go into the manufacture of a vast range of domestic and industrial products.

Like fossil fuels, nuclear fuels (principally uranium) are non-renewable. Once processed, their energy density is extremely high, but their processing, transport and waste disposal are difficult to achieve safely without enormous expenditure of energy and an adverse effect on the environment.

Artificial fertilizers

Artificial fertilizers can dramatically increase crop yields. Though alternative methods of achieving similar or nearly similar yields have been advocated, for example by the Soil Association[1], artificial fertilizers are quick and easy to apply, and in many countries agriculture is heavily reliant on them.

The principal chemical elements used in large quantities are potassium, nitrogen and phosphorus. Though these are all abundant, converting them into an agriculturally-useful form requires large amounts of energy, usually derived directly or indirectly from fossil fuels. Nitrate and urea-based nitrogen fertilizers are prime examples.

Construction materials

Buildings, transport infrastructure and machinery require large quantities of raw materials. Stone is a non-renewable raw material of mineral origin, though in most cases the environmental and energy impact of extracting, transporting and working it is of more immediate significance than its availability.

Brick, concrete, glass, and steel and other metals are also manufactured from mineral-derived raw materials. Apart from some of the rarer metals, most of the minerals involved are relatively abundant — but the amount of energy required to make the final material will increase progressively as the more easily-extracted deposits become worked out.

Timber is renewable, but only if the rate of logging does not outstrip the speed of replacement. Plastics, which are being used increasingly for construction purposes, are extremely energy-intensive to produce, and are often environmentally polluting.

Electrical and electronic goods

By weight, most electronic and electrical goods are composed mainly of plastic, glass, steel, aluminium and other fairly common constructional materials. But many of them also contain substantial amounts of less-common metals, such as copper, lithium for batteries and significant amounts of much rarer elements, such as cadmium or gold. Many of these are also toxic if discarded into the environment.

Competing demand for land

A large number of renewable materials are derived from biomass. Inevitably, there are competing demands on the finite amount of land available to grow crops for food, clothing (such as cotton) or energy (such as biofuels) — and the same land may also be in demand for timber. As the number of humans and the size of their economies increase, the pressure on productive land and the water supplies needed to grow anything on this land will inevitably also increase, giving rise to conflict.

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Recycling

Recycling is advocated by many, both to reduce the amount of pollution caused by waste materials and to conserve resources of raw materials. However, it should not be seen as a panacea for the environmental and resource-availability problems of our industrial economies.

Though recycling can greatly reduce the amount of (new) raw materials required, 100 per cent recycling is impossible in practice. Additionally, a great deal of energy is needed to recycle many materials back into products that are fit for purpose, as with scrap metal and paper.

Recycling is very seldom a better environmental option than using less of the material in the first place. Nor is it a better alternative to designing products with components which can be reused with minimal reprocessing once the original product reaches the end of its useful life.

Moreover, things that by their nature are transformed by use, such as food or fuel (whether renewable or not), are impossible to recycle. The best we can hope for may be to reuse their elemental constituents and some important molecular components.

Scarcity of materials

The majority of manufactured materials are made predominantly from chemical elements that are abundant in or on the earth's crust, oceans and atmosphere. So long as we are dealing with things made from these common elements, the ultimate limiting factor in their manufacture is more likely to be the energy required to convert the elements into useful forms than the absolute scarcity of the elements themselves.

On the other hand, the more dispersed the key elements become in the environment, and the lower grade the remaining mineral deposits, the more difficult and energy-expensive it will be to gather and convert them into useful materials. Aluminium, for example, is a major component of many rocks, but there are very few ores from which it can be extracted on an economic basis. In the case of rarer metals, the environmental cost of extracting even relatively small quantities is often already enormous in terms of energy and pollution.

Some scarcer elements are essential to many forms of life in very small quantities, i.e. as trace elements — iodine and selenium, for example. Natural processes have evolved allowing living things to concentrate these elements sufficiently to survive, but industry has more of a problem. Several very scarce elements, such as gold and cadmium, are used in substantial quantities because they have specific physical or chemical properties (for example in electronics, or as catalysts). Future developments in chemistry may lead to the development of substances made from common elements that can provide equivalent properties, but it would seem wise not to rely on this. We may have to accept that scarcity of crucial raw materials, and the cost of finding alternatives, might cause the microelectronics revolution to peter out.

Read about what the things we use are made of

References

Internet reference accessed 16/04/2016

[1] https://www.soilassociation.org/farmers-growers/technical-information/

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