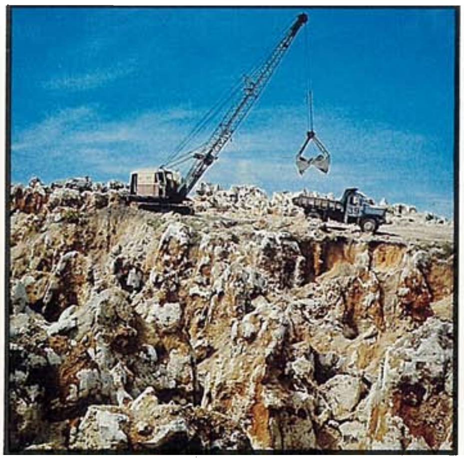
Outlook

Phosphorus, and feeding the world



Mining phosphate on Nauru.

Dr Millington.

Without phosphate fertilizers, the world could not grow enough food to support its present 4000 million people, let alone the 7000 million expected by the end of the century.

We're not about to run out of phosphorus. But it's worth remembering, when thinking about world population projections, that there are limits to the phosphate deposits that the fertilizers are made from. And very little of the phosphorus that is spread across the fields to boost crop yields and encourage pasture growth can be recovered and used again in fertilizers.

Dr Richard Millington of the CSIRO Division of Land Use Research recently drew together information on phosphate reserves and existing and expected use rates. He concludes that reserves should be adequate for at least 100 years and perhaps for several hundred.

But he also points out that there is no substitute for phosphorus, unlike some of the earth's other non-renewable resources. When oil and coal reserves run low, other energy sources may be able to take over, but nothing can replace phosphorus.

It is a fuel for biochemical activity; without it, no protein can be made so no life is possible. Of course, that doesn't mean that no life is possible without phosphate fertilizer. Phosphorus is about the twelfth most abundant element in the earth's crust, and it usually makes up between 0·05% and 0·2% of the material of rocks and soils.

In non-agricultural areas, plants take phosphorus from the soil and animals take it from the plants, but eventually they return it. However, when areas are cropped or grazed, some of the phosphorus taken from the soil is carried away in the farm products.

The inevitable result, unless phosphorus is returned to the soil, is a gradual decline in fertility and yields. This is offset to some extent by the gradual natural change of unavailable compounds of phosphorus in the soil to compounds that plants can take up. In fact, much of the phosphorus added in fertilizers changes to unavailable forms and does not contribute immediately to plant growth. But it adds to the supply in the soil that can gradually become available.

Yields fell

In Australia, average wheat yields per hectare fell by nearly half between 1870 and 1900; phosphorus depletion was almost certainly a major cause. Yields returned to their original levels after farmers began fertilizing with superphosphate late last century.

Asian farmers have known for centuries the value of manuring their fields; this returns phosphorus and other nutrients to the soil. But in most food-growing areas, a phosphorus input much greater than can be provided by the dung of farm animals is now needed to match food production with demand—hence the dramatic growth in use of phosphate fertilizers. In the United States, for example, the amount used per year nearly trebled between 1950 and 1970, and a similar increase was recorded in Australia. The high-yield crops responsible for the 'green revolution' in Asia and other parts of the world need much larger amounts than the crops they replace.

The phosphorus comes from rock phosphate, most of which—including big reserves in northern Queensland—formed on the sea bed. Phosphorus-rich water coming up from the cold depths of the ocean was probably the main source of this phosphate. It accumulated over millions of years on continental shelves that later came to the surface with changes in ocean levels and movements in the earth's crust.

Volcanic activity also produced large amounts of phosphate rock. The third major source was guano—the accumulated droppings of sea birds. Most of the phosphorus now used in Australia comes from phosphate rock that formed from massive guano deposits on Nauru and Christmas Island.

The reserves

Estimates of the world's reserves of phosphate rock vary widely, indicating a need for much more detailed mapping of deposits. The rock averages about 13% phosphorus. Dr Millington used the most recent, and highest, estimate in his calculations. This puts 'known' and 'potential' reserves of phosphorus at 20 000 million tonnes, contained in something like 150 000 million tonnes of rock.

The phosphate rock mined in a year now yields about 11 million tonnes of phosphorus. About four-fifths of the total ends up in fertilizers. Industries use the rest—to make, among other things, detergents, toothpaste, pharmaceuticals, and match-heads.

If production remained at this level, reserves should last for 1000 years or more. But use of phosphate fertilizers must increase rapidly if food production is to keep pace with world population growth, so the phosphate stock is not likely to last that long.

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The underdeveloped areas of Asia, Africa, and Latin America—the parts of the world where population is growing most rapidly—used an average of about 0·0025 tonnes of phosphorus per ha in 1966. A panel from the United States President's Science Advisory Committee calculated in 1967 that a tenfold increase would be needed if the areas then in production in those countries were to double their food output.

This would bring the application rate up to 0·025 tonnes per ha per year, about double the current level on Australia's wheat fields (0·012 tonnes per ha). In Australia the low rainfall restricts yields; if more water was available more phosphorus would have to be added to achieve the higher yields that would then be possible.

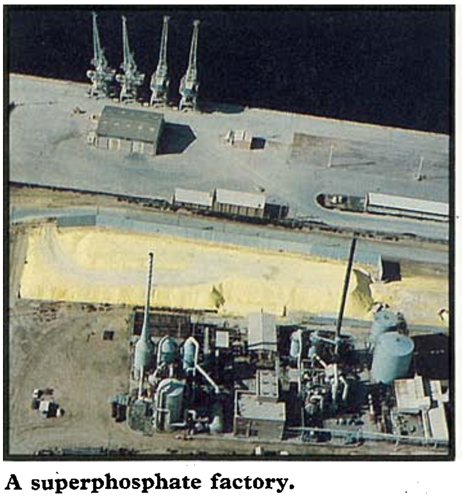
About half the 4000 million ha of the world that could be cropped are now in production. The balance, in general, is almost certainly less fertile, and the environmental consequences of bringing much of it into production would be vast. For example, huge areas of forest would have to be cleared.

But it seems certain that the area under crops will have to continue expanding if future food needs are to be met. And the land brought into production will have to be fertilized.

How long?

If the phosphate rock reserves estimate is accurate, and if fertilizer is spread over the total area that could be cropped at a modest average annual rate of 0·01 tonnes of phosphorus per ha, the reserves will last 500 years if used solely for agriculture. If one-fifth continues to be used for other purposes, the lifetime of the reserves will come down to 400 years.

Hopefully, it will never be necessary to crop all the land that could grow food. But average annual fertilizer requirements

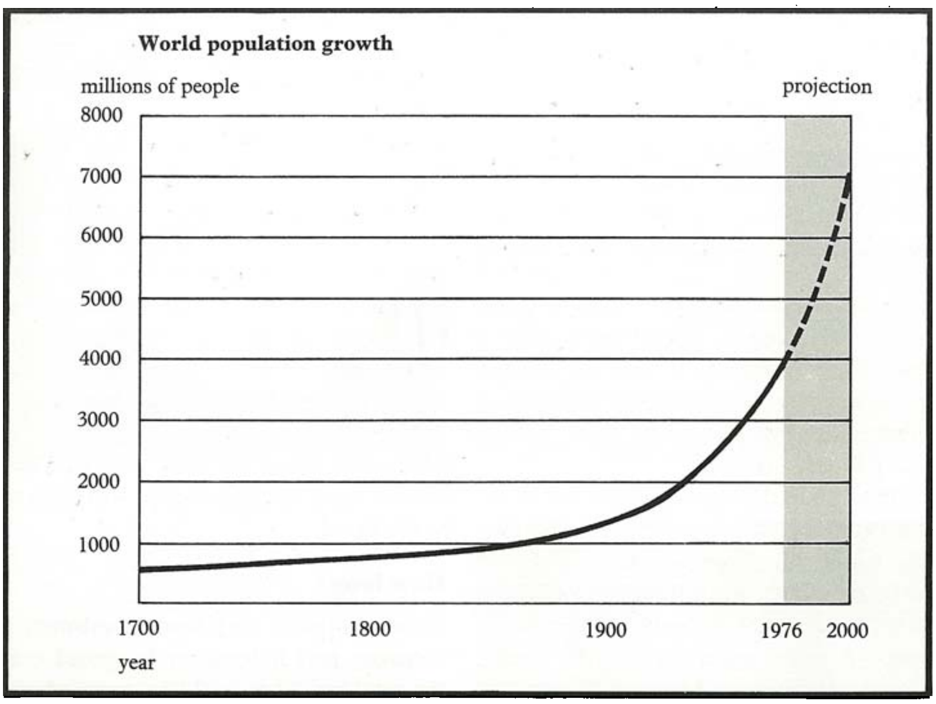


A superphosphate factory.

Superphosphate boosts crops . . .

. . . and pastures.

Discolouration from a Sydney sewage outlet. Some phosphorus could be recycled from sewage.



If food production is to keep pace with this increase, more and more fertilizer will be needed.

Spreading superphosphate.

seem likely to exceed 0·01 tonnes per ha in the not-far-distant future. Estimates prepared recently by a United States government commission on 'population growth and the American future' put world phosphorus requirements in the year 2020 at 90–230 million tonnes per year.

That is about 0·02–0·06 tonnes per ha averaged over the total area that could be cropped. At that rate of use, estimated phosphate rock reserves would disappear in something like 100–200 years.

Are there any alternative sources of phosphorus for fertilizers? Dr Millington believes coal may be able to provide a small proportion of future requirements. Coal has a very small phosphorus content —averaging only about 0·025%—but the reserves are so vast and the rate of extraction so rapid that useful quantities may be obtainable. Perhaps the phosphorus could be removed from the ash produced by large coal-burning operations such as power stations.

A recent estimate put the world's minable coal reserves at 7·6 million million tonnes. The phosphorus content is probably about 2000 million tonnes—one-tenth of the estimated reserves in phosphate rock. About 3000 million tonnes of coal are burnt throughout the world each year now—enough to yield 800 000 tonnes of phosphorus if all could be extracted from the ash. That is nearly one-tenth of present world use.

Ocean floor deposits

A bigger, but probably economically less attractive, potential source is phosphate deposits on the ocean floor. These are known to exist off the east and west coasts of the United States, off the west coasts of Central and South America, and off Japan and South Africa. No doubt other deposits exist that have not been discovered yet.

Mining companies have developed under-water techniques that could probably be used now to work some of the shallower deposits. But recovering this phosphorus would be an extremely expensive operation. No estimate is possible yet of the reserves that may prove accessible.

Only recycling could keep up phosphorus supplies indefinitely, and this doesn't seem possible in quantities anything like those now used in agriculture. The only big renewable source is sewage. But in Australia 20 times more phosphorus is spread in fertilizers each year than finds its way into the sewage systems.

Dr Millington believes the reason why the phosphorus supply-and-demand situation has received little attention so far is that relatively large resources are available now. He suggests, however, that 'with a resource or raw material for which there is no substitute, it is probably wise to look somewhat further ahead than 30–50 years as in the case of liquid fossil fuels'.

More about the topic

Phosphorus bio-economics. R. J. Millington. *Proceedings, Australian Institute of Agricultural Science (N.S.W. Branch) Symposium: Fertilizers and the Environment*, 1974, 67–73.