Impact of supply and demand on the price development of phosphate (fertilizer)

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Abstract In this paper the development of the phosphate price is investigated. The historical price development is analyzed and a prospect to the future development is given.

Generally the price is determined by the supply and demand situation. The phosphate reserves minable for the production of fertilizer are diminishing in quality and quantity. The mining of deeper soil layers leads to higher production costs and the phosphate rock is increasingly contaminated with heavy metals like cadmium and uranium. Consequently the quantity of phosphate economically minable at actual costs is decreasing. Additionally substantial costs for environment protection and transportation increase the phosphate price. Since 2007 the supply situation is tight due to production capacity shortage. For this reason the phosphate price increased rapidly. New mines and processing plants are supposed to be in operation by 2012. Most of the reserves are located in Africa and in the Middle East. Asian Countries, particularly India, are investing in processing plants to satisfy their increasing demand. The demand for phosphate is increasing due to population growth and the necessity of nurturing that population. The growth of energy plants for the production of agro-fuels is another factor that increases the phosphate demand. Since the development of agro-fuel production is difficult to predict, two scenarios – business as usual and increased agrofuel production – are distinguished. The phosphate price estimated for 2030 is about US$ 100 and 120 per tonne respectively in both scenarios.

INTRODUCTION

Phosphate reserves are diminishing in quantity and quality throughout the world. At the same time the demand for phosphate fertilizer grows due to the increasing food demand of a growing world population and, more recently, the demand for agro-fuels as renewable alternatives to fossil fuels. To ensure future supply of these agro-products it is important to take adequate measures now. Even though phosphate recycling from wastewater is one option to ensure future phosphate supply, it does not seem economically feasible yet. To strengthen research in this field a prospect of its economy and impact on the future supply will be helpful. This paper shows the development of the supply and demand

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situation for phosphates and from this makes conclusions for the future phosphate prices.

SUPPLY: P-RESERVES

The world's phosphate resources are hard to specify. The deposit of currently explored phosphate mines sum up to about 6,370 million tonnes [CRU, 2003]. An estimation of phosphate reserves that can be mined at costs lower than 40 $/t showed an amount of 12,000 million tonnes of phosphate rock in 2001. This is about one third of the world's total reserves [US Bureau of Mines, 2001 in FAO, 2004]. Some deposits might be used in the future with new mining technologies [FAO, 2004]. Other deposits are offshore and their mining is not likely.

Most of the profitably minable phosphate reserves are located in politically unstable countries in Northern Africa and the Middle East. Political decisions of local governments leading to the restriction of phosphate exports could therefore lead to a severe shortage in phosphate rock – including a strong impact on the phosphate price.

The increasing oil price affects the price of fertilizers in several ways. Rising transportation costs increase the price for phosphate imports. Furthermore, the production of phosphate fertilizer from phosphate rock requires ammonia and sulphuric acid. Especially the cost of ammonia production is strongly affected by increasing energy costs.

An upcoming problem with phosphate rock is heavy metals (e.g. cadmium, uranium) that contaminate the raw material. With a further exploitation of the mines the heavy metal content will tend to increase. The usual processing of phosphate rock to fertilizer does not eliminate heavy metals. Upgrading of the processing plants is technically feasible, but it increases the processing costs by more than 10 $/t. The German fertilizer ordinance, for instance, sets a maximum limit for cadmium of 1.5 mg/kg fertilizer and 50 mg/kg P_2O_5 for fertilizers with more than 5% P_2O_5. Table 1 shows that most mines can comply with this limit but there are some that could exceed the limit in the future when the mining proceeds to deeper soil layers.

In some countries like USA and Canada, environment protection requires cost intensive measures. Renaturation of the surface mining fields is an obligation for the mines. Costs can be very high and can even lead to the closure of mines.

In the phosphate business a general trend towards integrating further parts of the production chain exists. This includes the further processing of phosphate rock to phosphoric acid or P-containing fertilizers. The reason for this is the need

Table 1. Reserves and Heavy Metal contents of phosphate rock [Data from FAO (2004) and Duley (2001)].

Country	Deposit	P_20_5 (wt %)	As	Cd (ppm)	U	Reserves (1000 tonnes)	Reserve base (1000 tonnes)
Israel		32	5	25	150	180,000	180,000
Jordan		32	8	5	78	900,000	1,700,000
Morocco						5,700,000	21,000,000
	Bu Craa	35.1		37.5	75		
	Louribga	32.6	13.3	15.1	88		
	Youssoufia	31.2	9.2	29.2	97		
Togo		36.7	10	58.4	94	30,000	60,000
USA						1,000,000	4,000,000
	Florida	31.9	11.3	9.1	141		
	Idaho	31.7	23.7	92.3	107		
	N. Carolina	29.9	11.2	38.2	65		
S. Africa		39.5	11	<2	9	1,500,000	2,500,000
Tunisia		29.3	4.5	39.5	44	100,000	600,000
Senegal		35.9	17.4	86.7	67	150,000	1,000,000
China		31	26	2.5	22.8	500,000	1,200,000
Russia						150,000	1,000,000
others						1,200,000	4,000,000
World total						12,000,000	37,000,000

to satisfy a rapidly increasing fertilizer demand or to realize the higher profits associated with the higher value added by further processing phosphate products.

Phosphate supply in 2030

Today about 140 million tonnes of phosphate rock are mined. The amount of mined phosphate is increasing due to increasing fertilizer demand. With strong agro-fuel growth the amount of phosphate rock that needs to be mined will rise to about 171 million tonnes per annum in 2030. That means that in the time period until 2030 another 3,400 million tonnes of phosphate rock would have to be mined. This is about half the amount of the reserves of the currently operated mines.

DEMAND: P-CONSUMPTION

Current situation

In the CRU (2003) analysis of phosphate mines the total mining of P-Rock sums up to 126 million tonnes per year. From 2003 to 2006 an increase of the phosphate consumption of 10 million tonnes can be seen due to an increasing consumption in South and East Asia and Oceania. This increase exceeds the decreasing consumption in Western Europe and North America. More than 90% of all phosphate is used in agriculture.

Factors affecting the future fertilizer demand

Population growth: According to the statistics of the UN Population Division, the world population (2005 to 2050) grows by at least 1.3 billion in the low variant and by up to 4.2 billion in the high variant scenario. Even the low variant scenario represents a population increase by about 20%. In 2030 the world population will be about 9 billion people.

Nutrition: At the same time as the population increases the average income in developing countries is rising. This will lead to a better nourished population and an increasing need for further processed food (milk products, meat). For this reason the need for fertilizer is expected to increase more strongly than the population (see Figure 1).

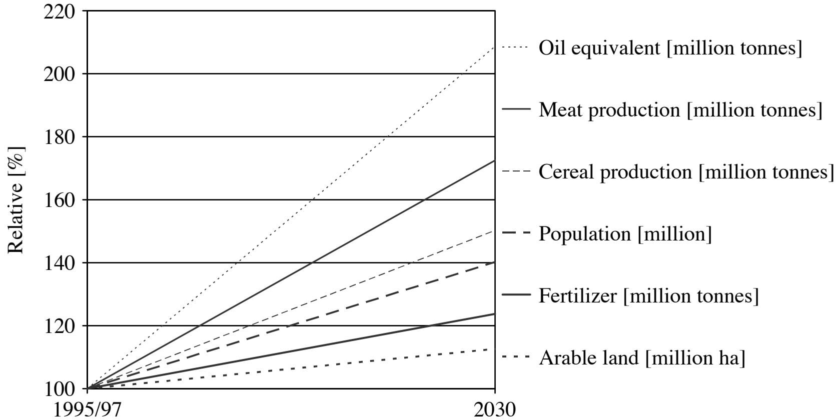

Figure 1. Development of factors affecting future fertilizer demand [FAO 2002, FAO 2000].

Farming technologies: The increase of the agricultural production has to be achieved mainly on the existing agricultural land as most of the arable land is already used. Only in South America and Sub-Saharan Africa further land can be made arable by clearing. The most important factors for crop increase on existing agricultural land are improved irrigation and fertilization. Like water, phosphate is essential for the growth of plants and can not be substituted.

Modern farming technology like precision farming can help to reduce the consumption of phosphate in agriculture by enabling a more precise adjustment of fertilizer supply to the specific local demand. Additionally, the use of precision farming can lead to an at least temporary decrease of the mineral fertilizer consumption in countries like Germany where agricultural land has partly been over-fertilized over many years by applying large amounts of manure to the cultured land.

Energy plants: The production of agro-fuels is increasing rapidly. The European Unions target is to increase the amount of agro-fuels used in transportation to 10% by 2020. At the same time there are ongoing debate as to whether the climate impact of agro-fuels is altogether positive if issues like land use change, GHG emissions from agriculture itself and water demand are included into the balance. With regard to these controversial discussions the future development of agro-fuel production is hard to predict. If however policy continues to consider the production of agro-fuels as a way out of the dependence on fossil fuels and the adverse effects on climate change, the increase in energy plant production will certainly result in a strong increase in fertilizer demand.

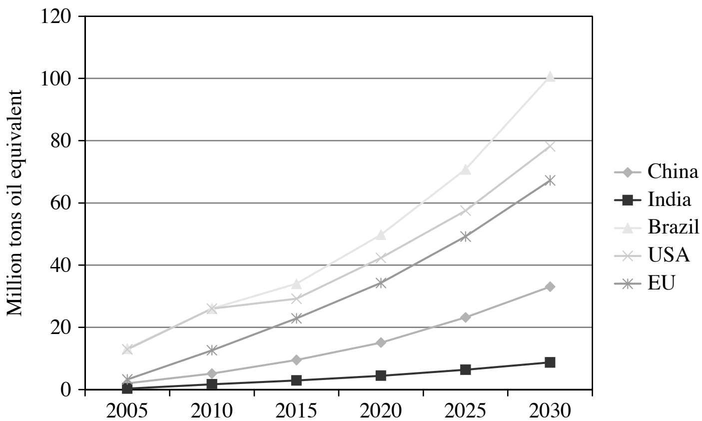

Figure 2. Production scenario for agro-fuels [Msangi *et al.*, 2007].

The production of biodiesel requires 100 kg NPK-Fertilizer per hektar. With a crop yield of 1.4 tonnes of biodiesel per hektar the fertilizer consumption for biodiesel production is 0.071 t NPK/t biodiesel. The agro-fuel scenario of Msangi *et al*. (2007) considers an aggressive agro-fuel growth (20% of transportation fuels by 2020) and no crop productivity change. Due to this scenario, the agro-fuel production is about 300 million tonnes in 2030. This would require about 21 million tonnes of NPK fertilizer. That means about 13% of the total fertilizer demand of 166 million tonnes in 2030 (FAO, 2000) will be used for energy plant production. According to FAO (2008) the fertilizer demand varies from 1% to 27.6% in different studies.

Phosphate demand in 2030

The FAO (2000) fertilizer forecast includes already the rising per capita income that leads to a higher fertilizer demand for nutrition, the increasing world population and the progress in farming technology that leads to a better fertilizer per crop yield. The increasing production of agro-fuels is not included in the forecast. Considering the terms shown in the energy plant chapter, an additional amount of 21 million tonnes of fertilizer are needed in 2030. Altogether the fertilizer demand will then be about 187 Million tonnes.

PRICE DEVELOPMENT

Actual and historical development

Phosphate is not traded globally. Instead fertilizer companies usually make long term contracts with locally specific phosphate mines. Therefore the phosphate rock market has an oligopolic structure. The phosphate rock price has been constant at about 30 $/t since 1990. In 2006 the price increased by 4.6 $/t, in 2007 an even greater increase in P-rock price of 12 $/t was recognized by CRU (2007). In 2008 the phosphate rock price jumped dramatically up to 200 $/t (see Figure 3).

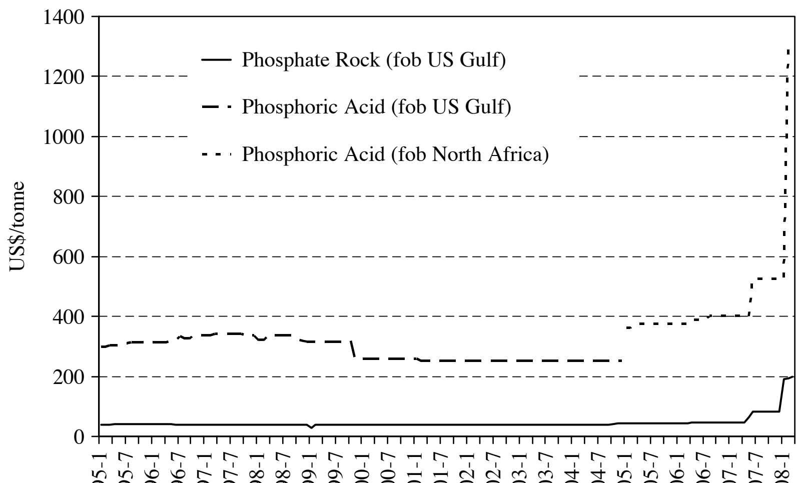

Figure 3. Phosphate price development (Fertilizer International, 2008).

The actual phosphate price is mainly influenced by the increasing demand for phosphate fertilizer. Since the year 2007, the current production capacity of mines, beneficiation and fertilizer plants are working at their maximum capacity. On the other hand, there is no substitute for phosphate in agriculture and, accordingly, the price elasticity of phosphate demand is very low. So, phosphate prices are expected to increase as long as demand increases and no new plant capacity will be in operation. The lack of production capacity is the main reason for the price increase.

For the last few years, the price for energy increased due to the high oil price. Although the conversion of phosphate is an energy intensive process the energy costs are less than 10% of the production costs in the phosphate fertilizer production. The high oil price however affects the transportations costs for phosphate. The transportation costs for coal increased by 100% in 2007. Phosphate transportation costs are supposed to respond to an increasing energy price in a similar way. Accordingly, the expected price increase for transportation from 10 $/t to 20 $/t may result in a price increase of more than 20% for Phosphate rock imports to the EU. At the same time, the high oil price is an important argument for processing plants are even more dependent on supply from the nearest phosphate mines. This further decreases the price elasticity and increases the rents actually realized by the phosphate mines.

To emphasize it again, the price jump is not caused by a shortage of phosphate reserves. Estimations show that the reserves minable at less than 40 $/t are available for the next 70 years at the current consumption level (FAO, 2004). The diminishing quantity and quality of phosphate reserves would not lead to a significant price increase yet.

Future development

Since in the past the producers of phosphate never undertook efforts to restrict their output below the actual demand and thereby realize substantial monopoly rents, we assume that they will respond also to this challenge by expanding the capacity of their facilities. Since capacities are actually being expanded for the extraction of a wide variety of resources and capacities find it difficult to even buy the necessary equipment, we further assume that the process of adjusting the capacity to the higher level will take at least 5 years starting from the beginning of the capacity shortage in 2007. For this adjustment period (until 2012), it will not be possible to determine a reasonable phosphate price, because the price elasticity of the demand is essentially unknown. The main reason for this is that the economic rule that suppliers will first satisfy the demand with the highest willingness-to-pay will not hold because policy may not allow poor farmers (with low willingness to pay) to be excluded from the access to fertilizers. So it is essentially unclear which demand will actually be satisfied in the case of a shortage of supply and who is going to pay which price for the required phosphate.

For the time after 2012, by contrast, we assume that a price determination on the basis of demand and supply will again be possible. On the supply side, we start our analysis with the actual supply curve showing in increasing order the total cost of phosphate production over all worldwide production capacities (CRU, 2003). The cost figures at the left and right end of the resulting steadily increasing graph respectively represent the lowest and highest costs of phosphate production at the time of investigation (2002). This supply curve is then extrapolated into subsequent years by assuming that the present cost curve is valid only for a static period of exploitation of 25 years and, accordingly, more costly production capacities have to replace the least costly exploitation opportunities running out every year. As a result, a cost range is yielded of which the lower and upper costs increase steadily over time. Figure 4 shows the estimation of the phosphate price until 2030 in a business-as-usual (BAU) scenario, that is, under the assumption that agricultural production and the respective fertilizer needs will develop as estimated by the FAO (2002).

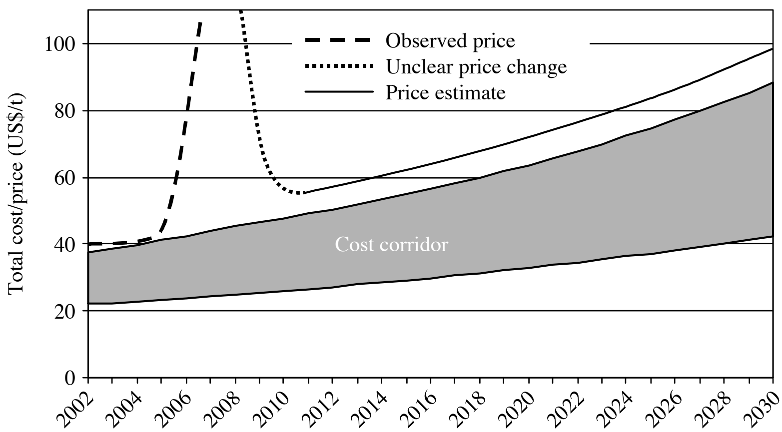

Figure 4. Prediction of the price development of phosphate rock in the business-as-usual scenario.

According to this picture it is unclear how the phosphate price will develop in the short term (by 2012) – which peak level it may reach and when exactly it will return. In the medium and long run, we are however confident that under the assumption of a profit margin of 10% a phosphate price of about 100 $ per tonne may be reached in 2030.

The move of the longer-term price curve at a margin of 10% above the upper cost limit goes with the assumption that in the future phosphate rock production facilities will always work close to their production capacity. This will cause more intense competition on the phosphate market which will lead to the formation of a more uniform phosphate price and the realisation of a moderate profit.

While in the business-as-usual scenario the fertilizer demand was expected to increase by 1% annually, we assumed an increase by up to 2% annually in the agro-fuel scenario, that is when agro-fuels will gain a substantial share (>20%) of the future agricultural production. In this case, the phosphate fertilizer demand would be similar to the BAU scenario until 2012, but up to 22% higher than in the BAU scenario in 2030. The phosphate price is estimated to eventually reach about 120 US$ per tonne.

CONCLUSIONS

The world's phosphate reserves are estimated to about 12,000 million tonnes. The currently operated mines have about 6,370 million tonnes of reserves. By 2030 these reserves will be diminished by half. Currently the phosphate price has jumped dramatically due to capacity shortage. New production capacity is under construction to satisfy the increasing fertilizer demand.

The phosphate demand is increasing due to population growth and a rising income in developing countries that leads to more sophisticated food preparation including more input per kilocalorie of taken up food. Furthermore increasing oil prices and concerns about the safety of oil supply enhances the cultivation of energy plants for agro-fuel production. In developed countries the fertilizer per crop yield improves due to precision farming. In total, the fertilizer demand will increase significantly to about 187 million tonnes per annum in 2030 due to these influences and energy plant growth.

In the phosphate price development, a long term slow price increase can be forecasted on the basis of the increasing fertilizer demand and the increasing efforts needed on the supply side to meet this demand. The more difficult accessibility and the decreasing quality of the reserves leads to higher processing costs that enhance the price increase – leading to phosphate prices of about 100 US$/t (without energy plants) or 120 US$/t (with aggressive energy plant cultivation) in the year 2030.

Phosphate recycling from wastewater will be self sufficient at costs of about 100 $/t. Especially for European countries without phosphate reserves even slightly higher prices might be acceptable to reduce the dependence on phosphate imports.

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