

Phosphogypsum production and utilization in China

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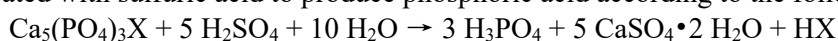
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Abstract. Phosphogypsum (PG) is a radioactive industrial by-product produced in large quantities when processing phosphate ores into fertilizers. With rapid growth of high concentration phosphate and compound fertilizers production in China, PG production is increasing every year. Phosphogypsum is usually stored in such a way that it not only occupies a large piece of land, but also leads to environmental pollution. Utilization approaches of PG are put forward in this document in order to provide the scientific support for the effective utilization.

1. Introduction

Phosphogypsum (PG), referred to specifically as gypsum, is an industrial by-product during processing phosphate ores into fertilizers. Normally production of one tonne (t) of phosphate fertilizer generates 4.5 to 5.5 t PG ^[1]. Phosphogypsum is formed as a by-product when phosphate ore (apatite) is treated with sulfuric acid to produce phosphoric acid according to the following reaction:



where X may include OH, F, Cl, or Br.

The major component of PG is $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. It also contains undecomposed phosphate rock, phosphate, CaF_2 , iron and aluminum compounds, acid insoluble materials, organic matter and a variety of other impurities, which can affect its utilization. The main impurities of PG are phosphorus, alkali metal salts, silicon, iron, aluminum, and magnesium. Some important components of PG are listed in Table 1 ^[2]. PG has been listed as a hazardous industrial by-product by the Chinese Ministry of Environmental Protection. As a result, the phosphate fertilizer industry is under great pressure for the safe storage and comprehensive utilization of PG.

Table 1. Some components of phosphogypsum (%) ^a.

CaO	SO ₃	Fe ₂ O ₃	Al ₂ O ₃	P ₂ O ₅	F	SiO ₂
26-37	39-51	0.08-3.31	0.08-2.65	0.47-1.28	0.05-0.26	0.1-5

^a Some data were cited from References of [2-4].

With rapid growth in the production of concentrated phosphate and compound fertilizers in China, PG production is increasing every year. However, its utilization is not increasing at the same pace. The storage of PG usually occupies a large piece of land, and has the potential for environmental pollution. As PG is now catching attention of planners and environmentalists, its utilization and environmentally friendly treatment are becoming an increasing concern in sustainable development.



2. Production of phosphogypsum in China

PG output continues to increase every year due to the rapid growth of concentrated phosphate and compound fertilizers in China, and poor advances in adopting the latest and modern technology and equipment. The production of PG in China was more than 10 Mt in 1995^[5]; it reached 40 Mt in 2006 and 68 Mt in 2011 (Fig 1). The cumulative production of PG during 2006 to 2011 was 315 Mt^[6]. In 2012, 80 Mt of PG was produced from 538 phosphate fertilizer plants, of which more than 234 were rated as large plants. In 2015, the production of PG in China reached 110 Mt^[7].

China is a huge agricultural country with a large demand for phosphate fertilizers. It has been predicted that the annual demand for phosphate fertilizers (calculated according to P_2O_5) will reach a peak value of 12.0~12.5 Mt during the period of 2010-2020. After 2035, the phosphate fertilizer demand will stabilize around 11 Mt every year^[7].

Production of PG will change accordingly. However, utilization of PG falls behind its production. Statistics for 2009 shows that in China the utilization rate of industrial by-product gypsum was about 38%. Utilization rate of desulfurization gypsum, PG and other by-products was 56, <20 and about 40%, respectively^[8]. In 2012, only 30% of the PG produced was used; about 60 Mt of unused PG was stored in the form of heaps^[7]. In 2013, the total amount of PG used was about 19 Mt, accounting for 23.3% of the total amount produced in that year.

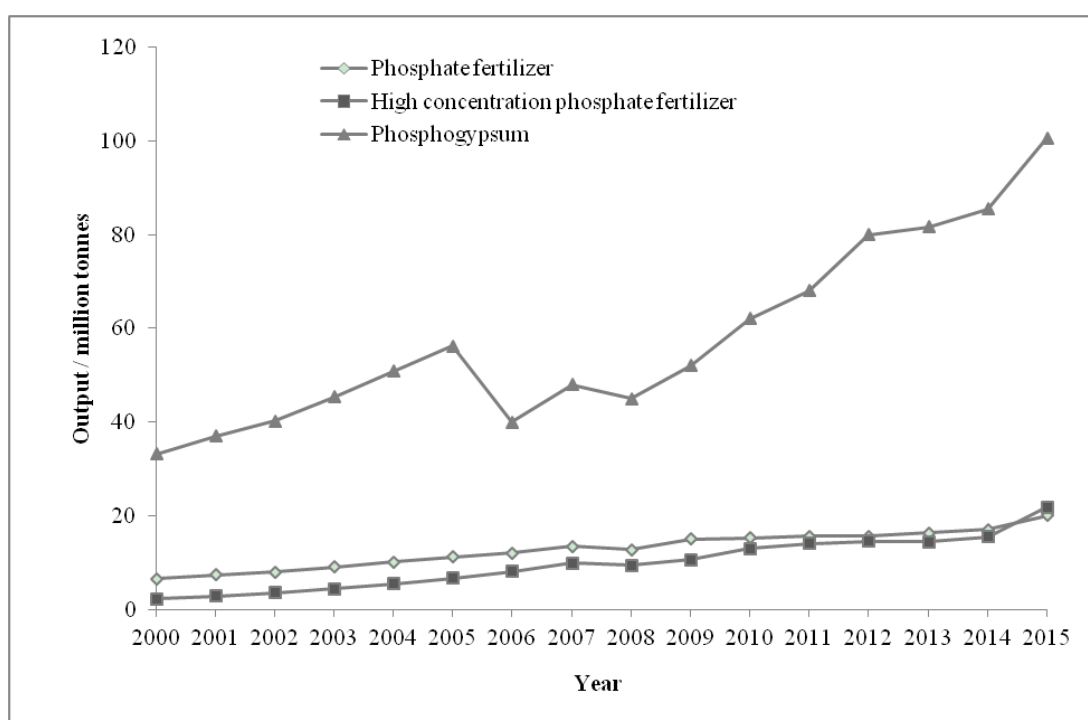


Figure 1. The production of phosphate fertilizer (as P_2O_5) and phosphogypsum in China during 2000-2015.

^a Some data were cited from references of [9-13].

3. Distribution of phosphogypsum in China

In 2014, total phosphate fertilizers (as P_2O_5) production in China was 17.09 Mt. The aggregate production in Yunnan, Guizhou, Sichuan and Hubei provinces was 12.53 Mt, accounting for 73.3% of the total production. The production in these provinces increased by 3.2% compared to that in 2013 (Fig 2). The top five provinces in phosphate fertilizer production were Hubei, Yunnan, Guizhou,

Sichuan and Anhui, with the output of 4.71, 4.35, 2.32, 1.16 and 0.85 Mt, respectively, which accounted for 78.3% of the total production (Fig 3).

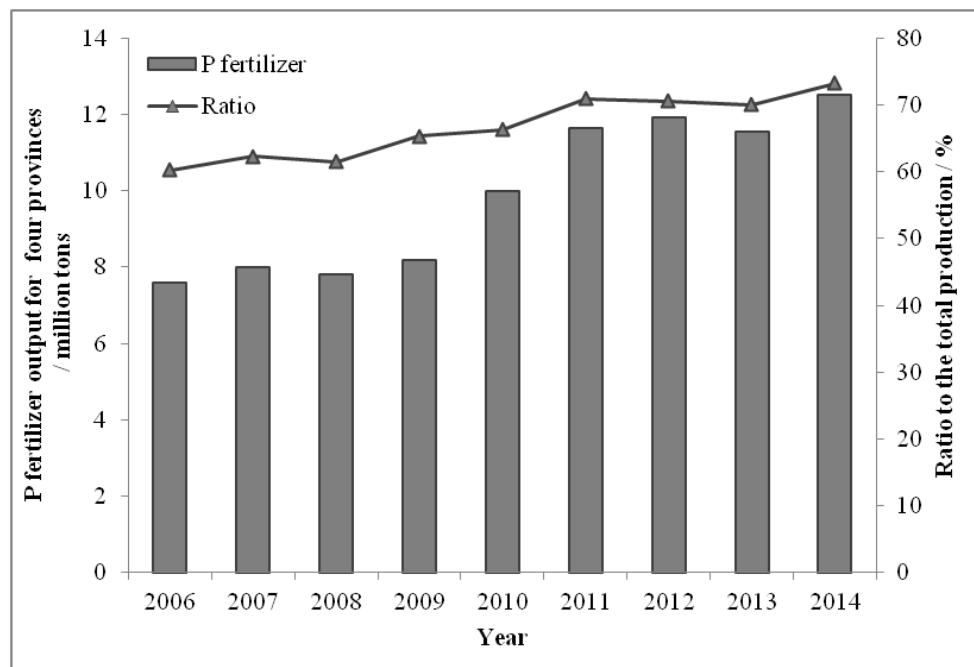


Figure 2. Production of phosphate fertilizers in Yunnan, Guizhou, Sichuan and Hubei provinces of China during 2006-2014.

Except in Beijing, Tianjin, Shanghai, Jilin, Heilongjiang, Hainan, Tibet, and Xinjiang provinces, PG is produced at the location of phosphate fertilizer production plants in all provinces of China. The top five provinces producing the largest amount of PG are Hubei, Yunnan, Guizhou, Sichuan and Anhui.

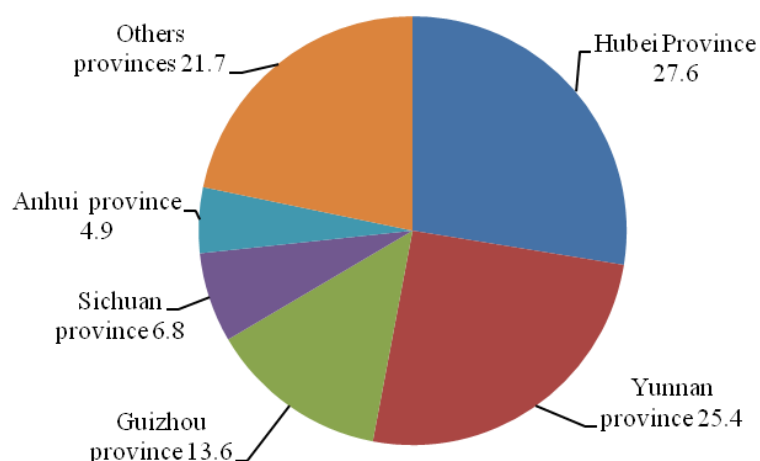


Figure 3. Production of phosphate fertilizers in different provinces in China.

4. Utilization of phosphogypsum

PG can be used^[10]: (i) As a chemical raw material for manufacturing sulfuric acid and cement. (ii) In making different products of gypsum building plasters. (iii) As a building material to make cement retarder and reinforced soft roadbed materials mixed with cement, sand and gravel. (iv) As source of nutrients in agriculture since it contains phosphorus, sulphur, calcium, magnesium and some other essential elements which plant needs. It can be used to produce potassium sulfate, ammonium sulfate, and compound fertilizers. And because of its acidic character, it also can be used for the reclamation of saline alkali soils. (v) As a filler in underground mines.

We focus on the application of PG in agriculture. PG can be used for improvement of both alkaline and acidic soils by: (i) slowing down soil degradation; (ii) increasing soil permeability, which can reduce the surface runoff and soil erosion; (iii) boosting the availability of the organic matter and phosphorus in the soil; (iv) improving salt washing and alkali leaching, preserving soil moisture, and protecting against drought and water logging; and (v) effectively reducing ammonia volatilization in composting process, and improving nitrogen use efficiency. Due to the low concentration of water-soluble fluorine in PG, it not only may increase fluoride pollution in soil, but also could reduce soil water-soluble fluorine content to a certain extent^[8].

5. Summary

With rapid growth in the production of high concentration phosphate and compound fertilizers in China, PG production is increasing every year. PG utilization and environmentally friendly treatment is becoming an increasing concern for sustainable development. PG is discussed in this document in order to provide the scientific support for the effective utilization. Comprehensive utilization of PG may greatly help in saving other precious resources and increasing economic benefits.

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