

SULPHUR AND PYRITES



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SULPHUR AND PYRITES

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**GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES**

Indira Bhavan, Civil Lines,
NAGPUR – 440 001

PHONE/FAX NO. (0712) 2565471
PBX : (0712) 2562649, 2560544, 25 6064 8
E-MAIL : cme@ibm.gov.in
Website: www.ibm.gov.in

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In India, there are no mineable elemental sulphur reserves. Pyrites was used as a substitute for sulphur in the manufacture of sulphuric acid by M/s Pyrites Phosphates and Chemicals Ltd (PPCL), however, there was no production of pyrites since 2003.

The domestic production of elemental sulphur is limited to by-product recoveries from petroleum refineries and fuel oil used as feedstock for manufacturing fertilizer. The sulphide ores contain sulphur and during the production of metal from sulphide ores, sulphur is released as SO₂ which is used to produce sulphuric acid. The sulphuric acid thus produced contains about 32.7% of sulphur and contributes in the industries which otherwise would have used elemental sulphur.

RESOURCES

Resources of sulphur (native) were estimated in the inferred (STD333) category. The resources are located in Jammu & Kashmir and are placed at 0.21 million tonnes as on 1.4.2010 as per UNFC System.

Total resources of pyrites in the country as per UNFC system as on 1.4.2010 are placed at 1,674 million tonnes. There are no reserves and all resources are grouped under 'remaining resources'

category. Of these, about 27 million tonnes are under feasibility (STD211) category. Out of the total resources, beneficiable grade resources are 62 million tonnes, low grade 1,555 million tonnes and soil reclamation grade resources are about 6 million tonnes. Balance of about 51 million tonnes resources fall under unclassified/not-known grades. Major resources are located in Bihar and Rajasthan (Table - 1).

PRODUCTION & STOCKS

Sulphur

The production of sulphur recovered as by-product from fertilizer plants and oil refineries were 429 thousand tonnes in 2014-15 as against 390 thousand tonnes in the preceding year.

The oil refineries in public sector reported production of sulphur during the year 2014-15, Indian Oil Corp. Ltd contributed about 85.53% of the total production during the year. Among the states, Haryana accounted 39.28%, Gujarat 20.99%, Maharashtra 13.44 %, West Bengal 11.57%, Uttar Pradesh 11.36%, Bihar 2.01% and the remaining 1.35 % was contributed by Assam.

**Table – 1 : Reserves/Resources of Pyrites as on 1-4-2010
(By Grades and States)**

(In '000 tonnes)

Grade/State	Remaining Resources							Total (B)	Total (A+B)
	Reserves Total (A)	Feasibility STD211	Pre- feasibility STD222	Measured STD331	Indicated STD332	Inferred STD333	Total		
All India : Total	–	27129	32597	9590	77729	1527356	1674401	1674401	
By Grades									
Soil Reclamation	–	–	3000	–	–	3024	6024	6024	
Beneficiable	–	27129	29597	–	–	4902	61628	61628	
Low	–	–	–	9590	26310	1519430	1555330	1555330	
Unclassified	–	–	–	–	51419	–	51419	51419	
By States									
Andhra Pradesh	–	–	–	–	–	880	880	880	
Bihar	–	13462	9680	–	51419	1500000	1574561	1574561	
Himachal Pradesh	–	–	–	–	–	2560	2560	2560	
Karnataka	–	–	–	–	–	3000	3000	3000	
Rajasthan	–	13667	22917	9590	26310	18392	90876	90876	
Tamil Nadu	–	–	–	–	–	24	24	24	
West Bengal	–	–	–	–	–	2500	2500	2500	

Figures rounded off.

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In addition, refineries of Hindustan Petroleum Corp. Ltd and RIL also recover by-product sulphur which is in turn used as feedstock in manufacturing fertilizers and pharmaceuticals. The Vadinar refinery of Essar Oil Ltd is also reported to produce by-product sulphur.

In fertilizer industry, the sulphuric acid is further used for manufacturing phosphoric acid and single superphosphate (SSP) from rock phosphate which is imported from Jordan, Egypt, Morocco, Togo, Israel, etc. (Tables - 2 to 4).

Pyrites

Pyrites Phosphates and Chemicals Ltd (PPCL) had two pyrites production units located at Amjhore (Bihar) and Saladipura (Rajasthan) besides phosphorite division in Dehradun. The Government approved closure and hiving off of these two units in July 2002 and Amjhore unit in June 2003 and hence no activity is reported.

Table - 2 : Principal Producers of By-product Sulphur, 2014-15

Name & address of producer	Location of plant/refinery	
	State	District
Indian Oil Corporation Ltd, (Refineries Division), Scope Complex, Core-II, 7, Institutional Area, Lodhi Road, New Delhi -110 003.	Assam	Guwahati Digboi Chirang
Numaligarh Refinery Limited, 122S, G. S. Road, Christanbasti, Dist: Guwahati, Assam - 781 005.	Bihar	Begusarai
	Gujarat	Baroda
	Haryana	Panipat
	Uttar Pradesh	Mathura
Bharat Petroleum Corporation Ltd, Bharat Bhavan, 4 & 6, Currimbhoy Road, Ballard Estate, Mumbai-440 001, Maharashtra.	West Bengal	Midnapur
	Assam	Golaghat
Bharat Petroleum Corporation Ltd, Bharat Bhavan, 4 & 6, Currimbhoy Road, Ballard Estate, Mumbai-440 001, Maharashtra.	Maharashtra	Mumbai

Table – 3 : Production of By-product Sulphur 2012-13 to 2014-15 (By States)

State	(In tonnes)		
	2012-13	2013-14	2014-15 (P)
India	449004	390325	429258
Assam	3706	4950	5803
Bihar	12345	10253	8629
Gujarat	74697	76088	90096
Haryana	218633	170471	168598
Maharashtra	46991	51301	57691
Punjab	12676	-	-
Uttar Pradesh	43574	35361	48782
West Bengal	36382	41901	49659

Table – 4 : Production of By-product Sulphur 2013-14 and 2014-15 (By Sectors/States/Districts)

State/District	(In tonnes)			
	2013-14		2014-15 (P)	
	No. of units	Quantity	No. of units	Quantity
India	10	390325	10	429258
Public sector	10	390325	10	429258
Assam	4	4950	4	5803
Chirang	1	397	1	720
Digboi	1	34	1	59
Guwahati	1	749	1	619
Golaghat	1	3770	1	4405
Bihar	1	10253	1	8629
Begusarai	1	10253	1	8629
Gujarat	1	76088	1	90096
Baroda	1	76088	1	90096
Haryana	1	170471	1	168598
Panipat	1	170471	1	168598
Maharashtra	1	51301	1	57691
Mumbai	1	51301	1	57691
Uttar Pradesh	1	35361	1	48782
Mathura	1	35361	1	48782
West Bengal	1	41901	1	49659
Midnapur	1	41901	1	49659

APPLICATIONS & USES

One of the direct uses of sulphur is in vulcanisation of rubber. Sulphur is a component of gunpowder. It reacts directly with methane to give carbon disulphide, which is used to manufacture cellophane and rayon.

Elemental sulphur is mainly used as a precursor to other chemicals. Most of the sulphur is converted to sulphuric acid (H_2SO_4), which is of prime importance to the world economy. The production and consumption of sulphuric acid is an indicator of a nation's industrial development. The principal use of the sulphuric acid is in the manufacture of phosphatic fertilizer. Almost all trials responded to sulphur fertilizer with increase in crop yield from 14% to 60%.

Other applications of sulphuric acid include oil refining, wastewater processing and mineral extraction. Sulphur compounds are also used in detergents, fungicides, dyestuffs and agrichemicals. In silver based photography, sodium and ammonium thio-sulphate are used as "fixing agents". Sulfitcs, derived from burning sulphur, are used to bleach paper. They are also used as preservatives in dried fruit and processed fruit products.

Sulphur is used as a light-generating medium in the rare lighting fixtures known as "sulphur lamps". The sulphur lamp is a highly efficient full-spectrum electrodeless lighting system whose light is generated by sulphur plasma that has been excited by microwave radiation.

CONSUMPTION

The total consumption of elemental sulphur in 2014-15 was about 2 million tonnes. The main consumer of sulphur was fertilizer industry which accounted for about 77%. (Table - 5).

TRADE POLICY

Imports of sulphur of all kinds other than colloidal sulphur, precipitated sulphur and sublimed (flowers) sulphur under heading No. 2503 are allowed freely under the Foreign Trade Policy, 2009-14. Similarly, the imports of unroasted pyrites under heading No. 2502 are allowed freely.

WORLD REVIEW

Reserves of sulphur in crude oil, natural gas and sulphide ores are large. Because most sulphur production is a result of the processing of fossil fuels, supplies should be adequate for the foreseeable future. Because petroleum and sulphide ores can be processed long distances from where they are

**Table – 5: Consumption of Sulphur*
2012-13 to 2014-15
(By Industries)**

(In tonnes)			
Industry	2012-13	2013-14 (R)	2014-15 (P)
All Industries	1960800	1996900	2027400
Alloy steel	3600(3)	3600(3)	3600(3)
Chemical	272800(34)	272800(34)	272800(34)
Explosive	1200(2)	1200(2)	1200(2)
Fertilizer	1503400(35)	1544500(36)	1555600(36)
Iron & steel**	16900(3)	16900(3)	16900(3)
Paint	2200(2)	2000(2)	2000(2)
Paper	3800(5)	3800(5)	3800(5)
Pesticide	24600(6)	24600(6)	24600(6)
Pharmaceutical	4100(5)	4100(5)	4100(5)
Rubber	2000(12)	2000(12)	2000(12)
Sugar	125900 ^(e)	121100 ^(e)	140500 ^(e)
Others	300(10)	300(10)	300(10)
(Abrasive, asbestos products, dry cells battery, electrical & glass)			

Figures rounded off.

Figures in parentheses denote the number of units in organised sector reporting consumption.*

*(*Paucity of data hence coverage may not be complete).*

*** The consumption relates to manufacturing sulphuric acid in the steel plants.*

(e) estimate based on sugar production.

produced, sulphur production may not be in the country to which the reserves were attributed. For instance, sulphur reserves from Saudi Arabia may be recovered at oil refineries in the United States or elsewhere in the world.

In 2014, the world production of sulphur was estimated at 74.9 million tonnes and that of pyrites at 8.2 million tonnes in terms of sulphur content. (Table - 6).

Elemental sulphur is obtained from ores by conventional mining or by the Frasch method of mining or as a by-product of sour natural gas processing, sour crude refining, tar sand processing and stack gas clean-up (recovered sulphur). Recovered sulphur production accounted for over 98% world elemental sulphur production.

In Frasch method, three concentric pipes are used. The outermost pipe contains superheated water, which melts the sulphur, and the innermost pipe is filled with hot compressed air, which serves to create foam and pressure. The resulting sulphur foam is then expelled through the middle pipe. The Frasch process produces sulphur with 99.5% purity content, and it needs no further purification. Frasch

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sulphur production on a commercial scale was operated in Brazil and Mexico. Elemental/native sulphur was mined in China, Poland and Russia.

Canada

Canada ranked fifth in the world in sulphur production. In 2014, sulphur production in Canada was about 5.9 million tonnes.

China

China was the leading producer of sulphur in all forms. It was also the world's leading producer of pyrites, with about 56% of its sulphur in all forms coming from that source. The country was the leading sulphur importer, fertilizer production consumed about two-third of the sulphuric acid produced in China.

**Table – 6 : World Production of Sulphur & Pyrites
(By Principal Countries)**

(In '000 tonnes of sulphur content)

Country	2012	2013	2014
World: Total (Sulphur)	74500	75200	74900
(Pyrites)	8000	8200	8200
Abu Dhabi (Sulphur)	975	902	-
Australia# (Sulphur)	975	902	-
Brazil (Sulphur)	478	438	440
(Pyrites)	21	17	20
Canada (Sulphur)	6259	6301	5914
China (Sulphur)	11889	12491	12475
(Pyrites)	7464	7704	7700
Chile (Sulphur)	1724	1770	1849
Finland (Pyrites)	375	347	353
(Sulphur)	461	446	466
Iran (Sulphur)	1890	1890	1900
Germany (Sulphur)	1291	1219	1146
Japan (Sulphur)	3503	3465	3451
Kazakhstan (Sulphur)	2739	3057	3069
Korea, Rep. of (Sulphur)	2603	2678	2528
Mexico (Sulphur)	1566	1584	1554
Poland (Sulphur)	1254	1066	1145
Russia (Sulphur)	7451	7096	7096
(Pyrites)	71	71	71
Saudi Arabia (Sulphur)	4092	3900	3800
South Africa (Sulphur)	257	250	250
(Pyrites)	-	-	-
USA (Sulphur)	8996	9216	9770
Other countries (Sulphur)	16097	16529	18047
(Pyrites)	69	61	56

Source : World Mineral Production, 2010-2014

FOREIGN TRADE

Exports

Exports of sulphur (excluding sublimed, precipitated and colloidal) decreased sharply to 3,97,399 tonnes in 2014-15 from 5,77,695 tonnes in the previous year. Exports were mainly to China (91%) and Jordan (8%) (Tables - 7 to 11).

Imports

Imports of sulphur (excluding sublimed, precipitated and colloidal) increased sharply to 16.26 lakh tonnes in 2014-15 from 12.89 lakh tonnes in the previous year. Imports were mainly from Qatar (31%), Saudi Arabia (29%) and UAE (20%) (Tables -12 to 16).

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**Table – 7 : Exports of Sulphur (Excl. Sublimed, Precipitated & Colloidal) : Total
(By Countries)**

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	577695	3949918	397399	3714082
China	464851	3125300	359821	3307385
Jordan	-	-	32870	312931
Bangladesh	1841	44301	1807	33851
Kenya	304	7093	862	17384
Nepal	791	14152	952	15047
Sri Lanka	903	16406	657	12177
UAE	65068	340417	106	3786
Tanzania Rep	18	837	115	2450
Italy	++	1	15	2037
Pakistan	6512	53869	32	1954
Other countries	37407	347542	162	5080

**Table –8 : Exports of Sulphur (Sublimed, Precipitated & Colloidal) : Total
(By Countries)**

Country	2013-14		2014-15(P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	14516	1782638	12770	1486491
Germany	2713	365361	2077	255276
Thailand	1368	165669	1500	175575
South Africa	1122	151612	1060	139407
Portugal	1008	130993	1032	124738
Slovak Rep	146	18500	916	111808
Turkey	829	109520	856	103441
Iran	726	84864	880	82143
Russia	564	76552	505	65266
Indonesia	715	76261	524	54054
UK	708	92732	405	53072
Other countries	4617	510574	3015	321711

**Table – 9: Exports of Sulphur (Colloidal)
(By Countries)**

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	90	4711	39	1047
Kuwait	-	-	18	690
Nepal	26	619	20	312
Uganda	-	-	++	28
Congo, D. Rep.	1	21	1	14
Qatar	-	-	++	2
UAE	++	16	++	1
Other countries	63	4055	-	-

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**Table-10 : Exports of Sulphur (Precipitated)
(By Countries)**

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	92	1872	155	3645
Bangladesh	-	-	148	3246
Haiti	-	-	5	184
Nepal	82	1593	2	180
Sri Lanka	10	278	++	29
UAE	++	1	++	4
South Africa	-	-	++	2
Other countries	-	-	-	-

**Table – 11 : Exports of Sulphur (Sublimed)
(By Countries)**

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	14334	1776055	12576	1481799
Germany	2713	365361	2077	255276
Thailand	1368	165669	1500	175575
South Africa	1122	151612	1060	139405
Portugal	1008	130993	1032	124738
Slovak Rep	146	18500	916	111808
Turkey	829	109520	856	103441
Iran	726	84864	880	82143
Russia	564	76552	505	65266
Indonesia	715	76261	524	54054
UK	708	92732	405	53072
Other countries	4435	503991	2821	317021

**Table – 12: Imports of Sulphur (Excl. Sublimed, Precipitated & Colloidal): Total
(By Countries)**

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	1289979	11002926	1626419	17446236
Saudi Arabia	426640	3544750	470959	5367389
Qatar	268346	2466142	502195	4997105
UAE	333156	2652907	321427	3295648
Kuwait	146906	1418740	175105	2059816
Bahrain	59998	458063	96623	1056315
Japan	24002	192874	39499	446956
Russia	1079	10224	10793	95795
Oman	2297	30674	5125	75606
Turkmenistan	-	-	2932	30681
Iran	27499	223086	1660	15607
Other countries	56	5466	101	5318

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**Table – 13: Imports of Sulphur (Sublimed, Precipitated & Colloidal): Total
(By Countries)**

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	5550	612338	3071	433481
USA	1690	218734	1614	226946
Malaysia	898	118970	963	135866
Chinese Taipei/ Taiwan	50	13312	77	20697
China	217	20668	179	16449
Japan	329	40429	125	16059
Germany	46	8833	73	14126
Korea, Rep. of	25	1635	34	2399
UK	21	2110	3	325
Baharain	-	-	2	297
Thailand	-	-	1	288
Other countries	2274	187637	++	29

**Table – 14: Imports of Sulphur (Precipitated)
(By Countries)**

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	2762	358742	2664	376121
USA	1492	192761	1404	197629
Malaysia	754	100589	899	126857
Chinese Taipei/ Taiwan	40	10494	70	18877
China	180	17053	151	13678
Japan	263	32755	84	11140
Germany	31	4808	53	7638
Korea, Rep. of	2	282	3	275
Turkey	-	-	++	25
France	-	-	++	2

**Table – 15 : Imports of Sulphur (Colloidal)
(By Countries)**

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	38	5302	68	11826
Germany	14	3811	19	6343
Korea, Rep. of	23	1345	30	1955
Chinese Taipei/ Taiwan	-	-	7	1819
Japan	1	137	9	1103
Bahrain	-	-	2	297
Thailand	-	-	1	288
USA	++	9	++	21

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**Table – 16: Imports of Sulphur (Sublimed)
(By Countries)**

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	2749	248037	339	45533
USA	198	25965	210	29295
Malaysia	144	18381	64	9009
Japan	65	7537	32	3815
China	37	3615	28	2770
UK	21	2120	3	325
Korea, Rep. of	++	7	1	169
Germany	1	214	1	145
Belgium	14	2229	++	5
Other countries	2269	187969	-	-

FUTURE OUTLOOK

Country being deficient in sulphur and pyrites which are essential for fertilizer industry, the Working Group on Mineral Exploration & Development (other than Coal & Lignite) for the 12th Five Year Plan (2012-17) has recommended that taxation policy intervention should be introduced to recover

the sulphur going as gaseous emissions in the refinery and petro-chemical industries.

Recovered sulphur output was expected to increase significantly worldwide. Increased production, was expected to come from Russia's increased sulphur recovery from natural gas and Asia's improved sulphur recovery at oil refineries and new development of sour gas deposits. Refineries in developing countries were expected to improve environmental protection measures and eventually, compare with the environmental standards of plants in Japan, North America and Western Europe in future. Higher sulphur recovery is likely to result from several factors, viz, higher refining rates, higher sulphur content in crude oil, lower allowable sulphur content in finished fuels, and reduced sulphur emissions mandated by regulations.

Some of the future gas production is expected to come from unconventional natural gas resources such as tight gas, shale gas and coal bed methane. Use of unconventional gas resources will certainly affect the sulphur supply outlook for the future as these gases have low sulphur content.