

SULPHUR AND PYRITES



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SULPHUR AND PYRITES

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**GOVERNMENT OF INDIA
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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). 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 was at 449 thousand tonnes in 2012-13 as against 381 thousand tonnes in the preceding year.

Two fertilizer plants and nine oil refineries, all in the public sector, reported production of sulphur during the year. Of the total quantity produced in 2012-13, Indian Oil Corp. Ltd contributed about 85.2% of the total production

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

(In '000 tonnes)

Grade/State	Reserves Total (A)	Remaining resources					Total (B)	Total (A+B)
		Feasibility STD211	Pre- feasibility STD222	Measured STD331	Indicated STD332	Inferred STD333		
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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during the year under review. Haryana accounted for 48.7%, Gujarat 16.6%, Maharashtra 10.5%, Uttar Pradesh 9.7%, West Bengal 8.1%, Punjab 2.8%, Bihar 2.7% and the remaining 0.8% was contributed by Assam (Tables - 2 to 4).

In addition, oil refineries of M/s Bharat Petroleum Corporation Ltd have reported production of 87,000 & 92,000 tonnes of by-product sulphur in 2011-12 and 2012-13, respectively. Data on recovery by Hindustan Petroleum Corp. Ltd is not available. Refineries of 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.

During the production of non-ferrous metals from sulphide ores, sulphur is recovered in the form of by-product sulphuric acid. HZL (Vedanta) and HCL together produced about 1.31 million tonnes and 1.20 million tonnes by-product sulphuric acid from indigenous lead-zinc and copper ores in 2011-12 and 2012-13, respectively, equivalent to about 428,000 tonnes and 392,000 tonnes of contained sulphur assuming 32.7% of sulphur in sulphuric acid. In addition, about 2.17 million tonnes and 2.20 million tonnes sulphuric acid equivalent to 710,000 tonnes and 719,000 tonnes of contained sulphur was indigenously produced from imported copper and zinc concentrates as by-product by Sterlite Industries, Binani Zinc Ltd and Hindalco Industries Ltd during 2011-12 and 2012-13, respectively. The total production of sulphuric acid from sulphide ores was thus about 3.48 million tonnes and 3.40 million tonnes, respectively, equivalent to about 1,138,000 tonnes and 1,111,000 tonnes of sulphur during 2011-12 and 2012-13, respectively (Table-5).

Sulphur consumption in the manufacture of sulphuric acid has been reported by some of the chemical and fertilizer industries. 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.

Pyrites

Pyrites Phosphates and Chemicals Ltd (PPCL) had two pyrites production units located at Amjhore (Bihar) and Saladipura (Rajasthan)

Table - 2 : Principal Producers of By-product Sulphur, 2012-13

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
Numaligarh Refinery Limited, Golaghat, Assam - 785 699.	Bihar	Begusarai
	Gujarat	Vadodara
	Haryana	Panipat
	Uttar Pradesh	Mathura
National Fertilizers Ltd, Scope Complex, Core-III, 7, Institutional Area, Lodhi Road, New Delhi -110 003.	West Bengal	Midnapur
	Assam	Golaghat
Bharat Petroleum Corporation Ltd, Bharat Bhavan, 4 & 6, Currimbhoy Road, Ballard Estate, Mumbai-440 001, Maharashtra.	Haryana	Panipat
	Punjab	Roopnagar
Bharat Petroleum Corporation Ltd, Bharat Bhavan, 4 & 6, Currimbhoy Road, Ballard Estate, Mumbai-440 001, Maharashtra.	Maharashtra	Mumbai

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. Hence, there was no production of pyrites since 2003.

Table – 3 : Production of By-product Sulphur 2010-11 to 2012-13 (By States)

State	(In tonnes)		
	2010-11	2011-12	2012-13 (p)
India	236998	381146	449004
Assam	3328	4968	3706
Bihar	8353	9329	12345
Gujarat	22436	65923	74697
Haryana	136622	174915	218633
Maharashtra	-	54850	46991
Punjab	2111	3407	12676
Uttar Pradesh	38856	36005	43574
West Bengal	25292	31749	36382

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**Table – 4 : Production of By-product Sulphur
2011-12 and 2012-13
(By Sectors/States/Districts)**

State/District	(In tonnes)			
	2011-12		2012-13 (P)	
	No. of units	Quantity	No. of units	Quantity
India/Public sector	11	381146	11	449004
Assam	3	4968	3	3706
Guwahati	1	777	1	552
Digboi	1	105	1	30
Golaghat	1	4086	1	3124
Bihar/Begusarai	1	9329	1	12345
Gujarat/Vadodara	1	65923	1	74697
Haryana/Panipat	2	174915	2	218633
Maharashtra/Mumbai	1	54850	1	46991
Punjab/Roopnagar	1	3407	1	12676
Uttar Pradesh/Mathura	1	36005	1	43574
West Bengal/Medinipur	1	31749	1	36382

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 thiosulphate are used as "fixing agents". Sulfites, 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 2012-13 was about 1.82 million tonnes. The main consumer of sulphur was fertilizer industry which accounted for about 72%. Chemical industry, the next important consuming industry, accounted for about 15% consumption for manufacturing carbon disulphide & dye-stuffs. Other industries like explosives, iron & steel, paint, paper, pesticides, pharmaceuticals and sugar consumed about 13% (Table - 6).

**Table – 5 : Production of By-product Sulphuric Acid, 2011-12 and 2012-13
(By Principal Producers)**

Name of Producer	Production	
	2011-12	2012-13
Hindustan Copper Ltd	3,539	6,304
Hindustan Zinc Ltd	1310,000	1193,478
A. Total : From Indigenous Ores	1313,539	1199,782
Sterlite Industries (India) Ltd	1026,471	1060,519
Binani Zinc Ltd	43,207	47,130
Hindalco Industries Ltd	1097,158	1097,158 ^e
B. Total : From Imported Ores	2166,836	2204,807
Grand Total : (A + B)	3480,375	3404,589

Source: Annual Reports 2012-13 of Respective Producers except Hindalco Industries Ltd.

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**Table – 6 : Consumption of Sulphur*
2010-11 to 2012-13
(By Industries)**

Industry	(In tonnes)		
	2010-11	2011-12(R)	2012-13(P)
All Industries	1726000	1774100	1816500
Alloy steel	3600(3)	3600(3)	3600(3)
Chemical	282700(34)	271100(34)	272800(34)
Explosive	1200(2)	1200(2)	1200(2)
Fertilizer	1261800(33)	1306800(34)	1315700(34)
Iron & steel**	24400(3)	24400(3)	16900(3)
Paint	2200(2)	2200(2)	2200(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	115300 ^(e)	130000 ^(e)	169500 ^(e)
Others (Abrasive, asbestos products, dry cells battery, electrical & glass)	300(10)	300(10)	300(10)

Figures rounded off.

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

(*Includes actual reported consumption and/or estimates made wherever required).

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

(e) estimate based on sugar production.

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 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.

**Table – 7 : World Production of Sulphur & Pyrites
(By Principal Countries)**

Country	(In '000 tonnes of sulphur content)		
	2010	2011	2012
World: Total (Sulphur)	69800	72300	72100
(Pyrites)	6800	7500	7600
Abu Dhabi (Sulphur)	1800	1875	1880 ^e
Australia [@] (Sulphur)	1026	1026	1025
Brazil (Sulphur)	430	460	470
(Pyrites)	25	18	20 ^e
Canada (Sulphur)	7472	6608	6183
China (Sulphur)	9604	11026	11000 ^e
(Pyrites)	6343	6964	7000 ^e
Chile (Sulphur)	1601	1650	1650 ^e
Finland (Pyrites)	250	338	375
(Sulphur)	392	1073	1130
Iran (Sulphur)	1500	1575	1600 ^e
Germany (Sulphur)	1968	2007	1953
Japan (Sulphur)	3710	3382	3447
Kazakhstan (Sulphur)	2873	2999	3000 ^e
Korea, Rep. of (Sulphur) ^e	1689	1738	1760 ^e
Mexico (Sulphur)	1417	1482	1531
Poland (Sulphur)	1020	1223	1261
Russia (Sulphur)	7355	7522	7570 ^e
(Pyrites)	71	71 ^e	71 ^e
Saudi Arabia (Sulphur)	3200	3250	3200 ^e
South Africa (Sulphur)	427	338 ^e	330 ^e
(Pyrites)	30	-	-
USA (Sulphur)	9081	8930	9050 ^e
Other countries (Sulphur)	13235	14136	14060
(Pyrites)	81	109	134

Source : World Mineral Production, 2008-2012.

@ : Including New Zealand.

In 2012, the world production of sulphur was estimated at 72.1 million tonnes and that of pyrites at 7.6 million tonnes in terms of sulphur content. China (15%), USA (13%), Russia (10%) and Canada (9%) were the major producers of sulphur. China (92%) and Finland (5%) were the major producers of pyrites (Table - 7).

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

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

FOREIGN TRADE

Exports

Exports of sulphur (excluding sublimed, precipitated and colloidal) increased sharply to 369,940 tonnes in 2012-13 from 163,372 tonnes in the previous year. Exports were mainly to China (89%), South Africa (5%) and Mozambique (4%).

Exports of sulphur (sublimed, precipitated and colloidal) sharply decreased to 11,155 tonnes in 2012-13 from 42,673 tonnes in the previous year. Sulphur (sublimed) alone accounted for 98% whereas the colloidal and precipitated sulphur together shared 2% exports in 2012-13. Exports were mainly to Germany, South Africa, Portugal, Indonesia, Thailand, etc. (Tables - 8 to 12).

Imports

Imports of sulphur (excluding sublimed, precipitated and colloidal) decreased sharply to 15.47 lakh tonnes in 2012-13 from 20.38 lakh tonnes in the previous year. Imports were mainly from UAE (21%), Iran (20%), Saudi Arabia (19%) and Qatar (14%).

Imports of sulphur (sublimed, precipitated and colloidal) increased sharply to 4,739 tonnes in 2012-13 from 2,981 tonnes in the previous year. Out of the total imports, 2,851 tonnes was precipitated sulphur, 1,635 tonnes colloidal sulphur and 253 tonnes sublimed sulphur (Tables -13 to 17).

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

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	163372	1671782	369940	3367000
China	102750	1002991	329334	2926687
South Africa	20	407	20020	168862
Mozambique	-	-	13267	127136
Bangladesh	2524	50471	2720	71472
Pakistan	-	-	1770	17812
Ethiopia	505	17940	618	16782
Sri Lanka	902	16147	683	13518
Kenya	166	3052	233	5552
Nepal	403	7346	271	4654
Sudan	299	6427	191	3878
Other countries	55803	567001	833	10647

Table – 9 : Exports of Sulphur (Sublimed, Precipitated & Colloidal) : Total (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	42673	1857142	11155	1344068
Germany	3091	354403	3430	436747
South Africa	1151	130820	1056	140907
Portugal	936	96924	821	98267
Indonesia	901	89477	606	66153
Thailand	590	66723	516	61856
Iran	669	72194	437	60065
Spain	862	101341	417	56235
Chile	330	35021	447	53458
Turkey	957	111400	394	51731
UK	487	51008	371	46476
Other countries	32699	747831	2660	272173

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**Table – 10 : Exports of Sulphur (Colloidal)
(By Countries)**

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	27506	281813	79	4353
Lebanon	28	2005	42	3326
Nepal	44	733	37	1017
Chad	-	-	++	5
Sri Lanka	-	-	++	4
Uganda	-	-	++	1
Other countries	27434	279075	-	-

**Table - 11 : Exports of Sulphur (Precipitated)
(By Countries)**

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	205	7003	104	2868
Bangladesh	-	-	65	1439
Nepal	74	1194	13	810
Sri Lanka	22	410	22	534
Saudi Arabia	-	-	4	79
UAE	1	16	++	6
Other countries	108	5383	-	-

**Table – 12 : Exports of Sulphur (Sublimed)
(By Countries)**

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	14962	1568327	10972	1336847
Germany	3091	354403	3430	436747
South Africa	1151	130820	1056	140907
Portugal	936	96924	821	98267
Indonesia	901	89477	606	66153
Thailand	590	66723	516	61856
Iran	561	66823	437	60065
Spain	862	101341	417	56235
Chile	330	35021	447	53458
Turkey	957	111400	394	51731
UK	487	51008	371	46476
Other countries	5096	464387	2477	264952

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

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	2037635	22832892	1547267	17358957
UAE	580163	6550779	319456	3754866
Iran	417611	4593722	304933	3389168
Saudi Arabia	83554	901715	294858	3268415
Qatar	494544	5636339	216596	2436985
Kuwait	213372	2348028	178881	1962373
Bahrain	59158	643539	108863	1156637
Morocco	550	5992	41813	405931
Chinese Taipei/ Taiwan	45	1131	16500	207421
Indonesia	1000	11869	13900	167949
Oman	32498	333065	13730	165525
Other countries	155140	1806713	37737	443687

**Table – 14 : Imports of Sulphur (Sublimed, Precipitated & Colloidal): Total
(By Countries)**

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	2981	268017	4739	399916
USA	147	14115	1437	166464
Malaysia	1155	125592	1014	123849
China	460	39496	362	34698
Canada	-	-	1604	28856
Japan	240	21955	82	10227
Germany	140	16256	49	9435
Chinese Taipei/ Taiwan	24	2270	33	7869
France	548	26191	32	3637
Vietnam	-	-	34	3534
Korea, Rep. of	96	9441	27	2364
Other countries	171	12701	65	8983

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

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	122	7019	1635	35208
Canada	-	-	1604	28856
Germany	12	2019	19	4260
Romania	-	-	3	655
South Africa	-	-	++	554
Saudi Arabia	49	338	2	479
Korea, Rep. of	27	2173	7	278
USA	34	2489	++	89
Japan	-	-	++	37

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

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	2217	197091	2851	338207
USA	95	9580	1422	165483
Malaysia	915	99843	886	109144
China	223	18570	277	26411
Japan	240	21955	82	10190
Chinese Taipei/ Taiwan	24	2270	33	7869
Germany	55	6007	29	4962
France	533	24642	32	3637
Vietnam Soc. Rep.	-	-	34	3534
Singapore	3	546	18	2340
Tanzania Rep.	-	-	18	2090
Other countries	129	13678	20	2547

**Table – 17 : Imports of Sulphur (Sublimed)
(By Countries)**

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	642	63907	253	26501
Malaysia	240	25749	128	14705
China	237	20926	85	8287
Korea, Rep. of	1	94	19	1954
USA	18	2045	15	892
UK	6	456	5	385
Germany	73	8230	1	212
Indonesia	-	-	++	54
Luxemburg	-	-	++	6
Singapore	-	-	++	6
Other countries	67	6407	-	-

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.