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CADMIUM

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GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

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3 Cadmium

Cadmium is a soft, bluish-white metal of low melting point which is present generally in zinc ore deposits as greenockite (CdS). The principal source of cadmium is zinc ore, sphalerite. Other sulphides and sulphosalts may also carry small amounts of the metal.

In India, cadmium is recovered as a by-product during zinc smelting and refining. The concentration of cadmium in sphalerite, the principal ore of zinc, ranges from 0.03 to 9.0 wt%.

INDUSTRY

The total annual installed capacity for recovering cadmium was 913 tpy of which HZL accounted for 833 tpy capacity. Binani Zinc Ltd (Edayar Zinc Ltd) reported the remaining 80 tpy capacity (Table-1). HZL produces cadmium of high quality in its zinc smelters which is casted in the form of pencils weighing from 250 g to 500 g. The purity is 99.95% Cd (max.) at Debari; 99.97% Cd (max.) at Vizag and 99.99% Cd (min.) at Chanderiya plants. HZL has plans to conduct R&D for production of high purity cadmium. High purity cadmium is typically used for nuclear shielding applications.

Table – 1 : Installed Capacity for Recovery of Cadmium

Unit	Location	Installed capacity (tpy)
Total		**913**
1. HZL, Debari Zinc Smelter	Debari, Distt. Udaipur, Rajasthan.	250
2. HZL,* Vizag Zinc Smelter	Visakhapatnam, Andhra Pradesh.	115
3. HZL, Chanderiya Lead-Zinc Smelter	Chanderiya, Distt. Chittorgarh, Rajasthan.	468
4. Binani Zinc Ltd** (Edayar Zinc Ltd)	Binanipuram, Distt. Ernakulam, Kerala.	80

** Operation suspended since 2002*
*** Operation suspended since April-2014*

USES

Cadmium is used to control the fissionable elements in nuclear reactors. Along with nickel, it is used in electrical storage/rechargeable batteries. Cadmium-based bearing alloys are used in high-speed internal combustion engines. Copper-cadmium alloys possess high strength, high conductivity and high resistance to abrasion, and therefore, the alloys are used in electric transmission wires. The main use of cadmium is in electroplating where it can be applied as a very thin coating to protect iron, steel, copper alloys and other metals and alloys from corrosion. Cadmium sulphide forms brilliant golden yellow, orange-red or reddish brown pigments used in paint, enamel, soap, rubber, glass and ceramic glazes. Some cadmium salts are also used in photographic films and in lithography. Cadmium coated products are preferred for a wide range of critical and safety-related applications in the aerospace, electrical, defence, mining, nuclear fission, television and offshore industries. Cadmium plating is used mainly in the aviation and aerospace industries to protect fastners exposed to hostile environments.

PRODUCTION & PRICES

Production of cadmium is generally reported as a by-product of zinc smelting. The production for the year 2018-19 was nil as compared to 47 tonnes in the previous year (Tables-2 and 3). The foreign market prices of cadmium are furnished in the General Review on "Prices".

Table – 2 : Production of Cadmium 2016-17 to 2018-19 (By State)

(Quantity in tonnes; Value in `'000)

State	2016-17		2017-18		2018-19 (P)	
	Qty	Value	Qty	Value	Qty	Value
India	35	4463	**47**	**5685**	-	-
Rajasthan	35	4463	47	5685	-	-

Table – 3 : Production of Cadmium, 2017-18 and 2018-19
(By Sector/State/District)

(Quantity in tonnes; Value in `'000)

State/District	Smelter	2017-18		2018-19 (P)	
		Quantity	Value	Quantity	Value
India		**47**	**5685**	-	-
Private sector		47	5685	-	-
Rajasthan					
Chittorgarh	Chanderiya/	47	5685	-	-
Rajsamand	Dariba/				
Udaipur	Debari				

RECYCLING

National Waste and Recycling Associations (NWRAs) have been created around the world to promote the collection and recycling of all batteries, both from the general public and industrial consumers. Nickel-cadmium batteries, which account for about three-fourths of the cadmium consumed, are virtually 100 per cent recyclable once they have been collected. The recovery of cadmium from cadmium products through recycing not only ensures that cadmium is kept out of the waste stream and out of the environment, but also that there is consumption of this valuable natural resource as well. Exide Industries Ltd, India's largest manufacturer of lead-acid storage batteries and power storage solutions provider , has invested in building a battery recycling plant at Haldia (West Bengal) and has plans to expand its existing facility to manufacture Nikel-Cadmium baterries. The plant in Haldia will have a monthly capacity of 15,000 tonnes, making it the country's largest lead recycling facility. With this project there will be a boost in the company's recycling capacity. It already operates two lead recycling plants near Pune and Bengaluru, which have a combined monthly capacity of 11,500 tonnes of recycled lead. The expansion project in Haldia is aimed at producing high-end Nickel-Cadmium batteries in technical collaboration with Furukawa of Japan. These batteries find applications in bullet trains, metro rail and other critical installations. This plant will also produce lead-acid batteries.

There are 9 major NiCd battery recycling plants located in the United States of America, Europe and Japan. This includes copper-cadmium alloy scrap, some complex non-ferrous alloy scrap and cadmium containing dust from electric arc furnace. India imports cadmium & scraps. However, the details of the recycling units are not available. As per JMK Research estimates, the lithium-ion battery market in India is expected to increase from 2.9 GWh in 2018 to about 132 GWh by 2030 (CAGR of 35.5%). Raasi Solar has announced plans to set up a 300MW plant focussing on lithium battery recycling along with battery assembling and cell manufacturing facility.

SUBSTITUTES

Suitable replacements of cadmium in all uses, especially in pigments and plating are being contemplated and enforced owing to the pollution hazards associated with the use of cadmium. NiCd batteries, in some applications, are replaced with lead-acid, fuel cells lithium ion and nickel metal hydride batteries. However, higher costs of these substitutes restrict their uses. Cadmium in plating applications can be substituted by coatings of zinc or vapour-deposited aluminium. Cerium sulphide is used as a replacement for cadmium pigments mostly for plastics. Cadmium telluride (CdTe) flexible thin film solar cells are an alternative to traditional crystalline silicon solar cells and are suitable for commercial roof top applications and large-scale ground mounted utility systems. CdTe photovoltaic cells are potentially safe, environment-friendly application for cadmium.

In India, cadmium is consumed in industries like paint, glass and chemical.

HEALTH AND SAFETY

Cadmium in all its chemical forms is considered highly toxic to living species as it does not decompose and if ingested through food, water and air it does not get excreted easily. It is both bioaccumulated and biomagnified. Ingested cadmium accumulates in liver, kidney, pancreas and thyroid. Excessive exposure to cadmium has been linked with respiratory insufficiency (via occupational exposure) and renal disturbance (via environmental and occupational exposure). Cadmium has also been implicated in the development of cancer of various types.

During the last decade, regulatory pressure to reduce or even eliminate the use of cadmium has gained momentum in many developed countries. The world recommended target guidelines for cadmium as a residual heavy metal below which no major risk is expected which could have significant or adverse impact on aquatic biota or human use is 0.1 mg/l. In the USA, Federal and State agencies regulate cadmium content in the environment. Cadmium present in CRT screens, printer inks, toners, etc. is known to cause health hazards affecting the kidneys and causing flue like symptoms and muscular pain. In India, the Silver Jewellery Industry is an important cadmium consuming industry. Silver mixed with cadmium is used in the making of silver jewellery.

WORLD REVIEW

Cadmium is generally recovered from zinc ores and concentrates. Sphalerite, the most economically significant zinc ore mineral, commonly contains minor amounts of cadmium, which shares certain similar chemical properties with zinc and often substitutes for zinc in the sphalerite crystal lattice. The cadmium mineral greenockite is frequently associated with weathered sphalerite and wurzite. Zinc-bearing coals of the Central United States and Carboniferous Age coals of other countries also contain large subeconomic resources of cadmium. Zinc-to-cadmium ratios in typical zinc ores range from 200:1 to 400:1. Quantitative estimates of reserves are not available. Cadmium content of typical zinc ore averages about 0.03%.

The world production of cadmium was estimated at 25,600 tonnes in 2018. Most of the world's primary cadmium is produced mainly in China, Republic of Korea, Japan, Canada, Kazakhstan, Mexico, Russia and Peru. As per Mineral Commodity Summaries, 2020 of USGS Report, the world refinery production of cadmium was estimated at 25,100 & 25,000 tonnes in 2018 & 2019, respectively.

World's secondary cadmium production accounted for 20% of the total metal production. Most secondary metal is produced at NiCd battery recycling facilities in Asia, Europe and the United States. China, Belgium and Japan are by far the world's largest consumers of cadmium. The world production of cadmium during 2016 to 2018 by principal countries is furnished in Table-4. To provide a generalised view of the development in various countries, the countrywise description sourced from latest available publication of Minerals Yearbook 'USGS' 2016 is furnished as below.

Australia

In 2016, Nyrstar was in the process of increasing its crude cadmium production capacity at its lead smelter in Port Pirie, South Australia. The capacity expansion was part of a larger project at Port Pirie to enable the smelter to treat a wider range of feedstock and to update the facility's environmental controls. The new capacity was commissioned in September. Port Pirie produced a crude cadmium product, which must be further refined to produce pure cadmium metal. Nyrstar's zinc smelter in Hobart, Tasmania was the sole producer of refined cadmium metal in Australia in 2017.

Belgium

Flaurea Chemicals [owned by Aurea SA (France)] used cadmium to produce cadmium compounds including cadmium chloride, nitrate and oxide and cadmium powder at its manufacturing facility in Ath. Cadmium compounds and powder were used mainly in coatings, paint pigments, NiCd batteries, PVC stabilizers, surface treatments and thin-film solar panels. In 2016, Belgium imported 2,890 t of cadmium, mostly from France, Mexico, the Netherlands and Poland.

Canada

Teck Resources Ltd produced refined cadmium metal and cadmium compounds at its metallurgical complex in Trail, British Columbia. Cadmium metal products included balls, billets and sticks for NiCd

battery manufacturing and continuously cast cadmium sheet for radiation shielding. HudBay Minerals Inc.'s copper smelting and zinc refining operations in Flin Flon, Manitoba, also produced cadmium metal. In 2016, Canada produced 2,305 t of cadmium, almost twice as much as in 2015 and exported 2,120 t mostly to China (92%) and Sweden (21%).

Republic of Korea

Korea Zinc's Onsan zinc-lead refinery had the capacity to produce 3,000 t/yr of refined cadmium and Young Poong Crop.'s Sukpo zinc refinery had the capacity to produce 1,750 t/yr of cadmium. Most of the cadmium produced in the Republic of Korea was exported to China and India.

Mexico

The Instituto Nacional de Estadísticay Geografía (2017) reported that Mexico produced about 1,188 t of cadmium in 2016, 7% less than that in 2015. According to data reported by the two known producers, the total cadmium production in 2016 was about 1,280 tonnes. Industrias Peñoles S.A.B. de C.V.'s Met-Mex metallurgical complex in Torreon produced 579 t of cadmium in 2016, 13% less than that in 2015, and Grupo Mexico S.A.B. de C.V.'s zinc smelter in San Luis Potosi produced about 700 t of cadmium in 2016, slightly more than that in 2015. Most of Mexico's cadmium production was exported to Belgium, China and the United Kingdom.

Table – 4 : World Production of Cadmium (By Principal Countries)

(In tonnes)

Country	2016	2017	2018
World: Total (rounded)	**25700**	**25800**	**24400**
China	8222	8200[e]	8200[e]
Korea, Rep. of	4000	4000	4900
Japan	1989	2310	2108
Russia	1500*	1800*	1900*
Canada[(a)]	2305	1802	1676
Kazakhstan	2682	1500[e]	1500[e]
Mexico	1244	1142	1307
Peru	820	797	765
Netherlands[(e)]	620	620*	620*
USA[e]	400*	550*	550*
Germany	400[e]	500	500
Norway[(e)]	355*	416*[e]	399*
Other countries	1146	1119	1148

Source: *BGS, World Mineral Production, 2014-18.*

**Estimated*

a) including cadmium sponge and/or secondary metal.

FOREIGN TRADE

Exports

Exports of Cadmium decreased to 128 tonnes during 2018-19 from 182 tonnes in the previous year. Exports were mainly to Bangladesh (89%) and Pakistan (10%). Exports of cadmium (including waste & scrap) decreased to 145 tonnes during 2018-19 from that of 202 tonnes in the previous year.

Exports of cadmium & alloys decreased to 122 tonnes during 2018-19 as against 174 tonnes in the previous year. Exports of cadmium & scrap were even at 18 tonnes in both 2017-18 & 2018-19. Exports of cadmium unwrought and powders decreased to 6 tonnes as compared to 7 tonnes in the previous year (Tables-5 to 9).

Imports

Imports of cadmium increased slightly to 6,904 tonnes in 2018-19 from 5,409 tonnes in the previous year. Imports of cadmium (including waste & scrap) increased to 8,898 tonnes in 2018-19 form 6,519 tonnes in the year 2017-18. The imports comprised 6,861 tonnes of unwrought & powders and 1.994 tonnes cadmium & scrap besides 43 tonnes of cadmium & alloys in 2018-19. Imports of cadmium were mostly from China (21%), Japan (14%), Republic of Korea (12%), Mexico (9%) and Peru (7%) (Tables-10 to 14).

Table – 5: Exports of Cadmium (By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**182**	**17593**	**128**	**17507**
Bangladesh	177	16831	114	15106
Pakistan	3	464	13	1816
Mexico	-	-	++	247
Saudi Arabia	-	-	++	142
Nepal	1	68	1	91
UAE	1	134	++	63
Myanmar	-	-	++	37
Qatar	-	-	++	5
Iran	++	53	-	-
Iraq	++	30	-	-
Other countries	++	11	++	++

Figures rounded off

Table – 6: Exports of Cadmium (Including Waste & Scrap) (By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**202**	**20077**	**145**	**20127**
Bangladesh	190	18438	124	16564
Pakistan	9	1256	19	2767
Mexico	-	-	++	247
Qatar	-	-	1	142
Saudi Arabia	-	-	++	142
Nepal	1	68	1	91
UAE	1	149	++	63
Myanmar	-	-	++	57
Oman	-	-	++	30
Iraq	++	30	++	14
Other countries	1	136	++	10

Figures rounded off

Table – 7: Exports of Cadmium & Alloys (By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**174**	**17015**	**122**	**16424**
Bangladesh	169	16256	112	14801
Pakistan	3	464	9	1278
Mexico	-	-	++	247
Nepal	1	68	1	71
Saudi Arabia	-	-	++	22
Qatar	-	-	++	5
UAE	1	134	-	-
Iran	++	53	-	-
Iraq	++	30	-	-
Lebanon	++	9	-	-
Other countries	++	1	++	++

Figures rounded off

Table – 8: Exports of Cadmium & Scrap (By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**18**	**2485**	**18**	**2621**
Bangladesh	13	1607	10	1457
Pakistan	5	792	7	951
Qatar	-	-	1	138
Oman	-	-	++	30
Myanmar	-	-	++	20
Iraq	-	-	++	14
Bhutan	-	-	++	9
Philippines	-	-	++	2
Indonesia	++	72	-	-
UAE	++	14	-	-

Figures rounded off

Table – 9: Exports of Cadmium: Unwrought, Powders (By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**7**	**576**	**6**	**1083**
Pakistan	-	-	4	538
Bangladesh	7	575	2	306
Saudi Arabia	-	-	++	119
UAE	-	-	++	63
Myanmar	-	-	++	37
Nepal	-	-	++	21
Sri Lanka	++	1	-	-

Figures rounded off

Table – 10: Imports of Cadmium
(By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**5409**	**660019**	**6904**	**1347545**
China	++	27	1470	292247
Japan	1298	160492	963	198611
Korea, Rep. of	1135	148252	822	173400
Mexico	517	63782	602	111648
Peru	532	59720	480	93742
Switzerland	-	-	412	76012
Hong Kong	-	-	417	73622
UAE	70	7786	356	69829
UK	++	73	328	66678
Belgium	60	7029	312	60712
Other countries	1797	212858	742	131044

Figures rounded off

Table – 11: Imports of Cadmium
(Including Waste & Scrap)
(By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**6519**	**800455**	**8898**	**1742742**
China	160	18334	1955	384891
Japan	1614	197642	1577	319133
Korea, Rep. of	1525	201321	1302	273225
Mexico	517	63782	663	123403
Peru	550	61797	520	101289
Switzerland	-	-	412	76012
Hong Kong	-	-	417	73622
UAE	70	7786	356	69829
UK	++	73	328	66678
Russia	426	58042	308	63717
Other countries	1657	191678	1060	190943

Figures rounded off

Table – 12: Imports of Cadmium & Alloys (By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**++**	**208**	**43**	**4410**
China	++	27	43	4211
USA	++	26	++	109
Germany	++	82	++	48
Canada	-	-	++	42
UK	++	73	-	-

Figures rounded off

Table – 13: Imports of Cadmium: Unwrought, Powders (By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**5409**	**659811**	**6861**	**1343137**
China	-	-	1427	288036
Japan	1298	160492	963	198611
Korea, Rep. of	1135	148252	822	173400
Mexico	517	63782	602	111648
Peru	532	59720	480	93742
Switzerland	-	-	412	76012
Hong Kong	-	-	417	73622
UAE	70	7786	356	69829
UK	-	-	328	66678
Belgium	60	7029	312	60712
Other countries	1797	212750	742	130847

Figures rounded off

Table – 14: Imports of Cadmium & Scrap (By Countries)

Country	2017-18		2018-19	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**1110**	**140434**	**1994**	**395195**
Japan	316	37150	614	120522
Korea, Rep. of	390	53069	480	99825
China	160	18307	485	92644
Russia	43	6635	120	25935
Malaysia	-	-	60	13052
Mexico	-	-	61	11755
Germany	-	-	40	9269
Peru	18	2077	40	7547
Brazil	25	2460	56	7288
Netherlands	38	5063	20	4126
Other countries	120	15673	18	3232

Figures rounded off

FUTURE OUTLOOK

The world cadmium market based on the world production of cadmium does indicate a fluctuating trend. While the primary cadmium supply is on decrease, there is a modest rise in production through recycling. Though cadmium consumption in various applications is clamoured with concerns over its toxicity and hazardous effect on human health and environment, the production of cadmium as a by-product will, however, continue as long as lead and zinc are produced.

The demand for cadmium is increasing owing to several new market opportunities for NiCd batteries, particularly, in industrial applications. NiCd battery had been favoured for use in less expensive consumer appliances and elecrtonics owing to their cost advantage over other battery chemistries. During the past few years, lithium-ion batteries have significantly replaced NiCd batteries in some low-cost electronics and substitution is expected to contiune as the manufacturing cost of lithium-ion batteries decreases and their electrical storage capacity increases.

NiCd batteries, however, are expected to continue to be used in certain industrial applications because of their superior reliabilility and stability compared with the other rechargeable battery technologies. NiCd batteries power some battery-powered electric vehicles and are also used in a limited number of hybrid electric vehicles. NiCd batteries are also used as buffers in transportable, renewable hybrid-power systems developed to generate electricity in remote locations and in underdeveloped regions. Industrial-sized NiCd batteries potentially could be used to store energy produced by certain on-grid solar or wind systems. Excess energy generated during periods of low electricity demand could be stored in batteries, from which it would later be dispatched during periods of high electricity demand. NiCd may be a favoured battery chemistry for this use owing to its stability in offshore and harsh weather environments. NiCd battery is used in electrical vehicles albeit in limited number in hybrid electrical vehicles and has been making important contribution to the development of the electric car market in Europe.

Cadmium pigments and stabilisers are important additives in certain specialised plastic, glasses, ceramics and enamels which enable to achieve bright colours along with long service life, even in very demanding applications. It should also be emphasised that cadmium in these applications is in a chemically very stable, highly insoluble form and is embedded in the product matrix.